THE

Psychological Review

EDITED BY

J. McKEEN CATTELL
COLUMBIA UNIVERSITY

AND

J. MARK BALDWIN
PRINCETON UNIVERSITY

WITH THE CO-OPERATION OF

ALFRED BINET, ÉCOLE DES HAUTES-ÉTUDES, PARIS; JOHN DEWEY, UNIVERSITY OF CHICAGO; H. H. DONALDSON, UNIVERSITY OF CHICAGO; G. S. FULLERTON, UNIVERSITY OF PENNSYLVANIA; JOSEPH JASTROW, UNIVERSITY OF WISCONSIN; G. T. LADD, YALE UNIVERSITY; HUGO MÜNSTERBERG, HARVARD UNIVERSITY; M. ALLEN STARR, COLLEGE OF PHYSICIANS AND SURGEONS, NEW YORK; CARL STUMPF, UNIVERSITY, BERLIN; JAMES SULLY, UNIVERSITY COLLEGE, LONDON.

Series of Monograph Supplements,

Vol. II., No. 1, (Whole No. 5), December, 1897.

PROBLEMS

IN THE

PSYCHOLOGY OF READING

BY

J. O. QUANTZ, PH. D.

PUBLISHED BI-MONTHLY BY
THE MACMILLAN COMPANY,
41 N. QUEEN ST., LANCASTER, PA.
66 FIFTH AVENUE, NEW YORK; AND LONDON.

PRESS OF
THE NEW ERA PRINTING COMPANY,
LANCASTER, PA.

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PROBLEMS IN THE PSYCHOLOGY OF READING.

§ I. Introductory.

In an age when the thinker writes his best thoughts and the investigator records his most important discoveries, when almost the sum-total of human knowledge is preserved in the form of books, and he whose ambition is scholarship spends his days in the alcoves of some great library, it needs no argument to show that a large part of the culture of modern life depends upon this source of information. If in these days 'the true university is a collection of books,' and that university is extending indefinitely, it is clearly important that we should understand the art of gaining the most from an author's words with the least expenditure of time and energy. We have books and articles innumerable telling us, from both the literary and the pedagogical point of view, how to read. But the psychical processes involved in reading have not been experimentally investigated. On the physiological side much has been done[1]; but psychologically, almost nothing. The present research[2] is an attempt to consider some of the problems which are presented in the processes of ordinary reading: for example, What are the factors which make a rapid reader? Does rapidity depend on mental capacity, alertness of mind, quickness of visual perception, amount of practice—on any or all of these? What sensory type of persons obtains and retains most—those who gain their knowledge principally through the eye, or through the ear?

[1] Some of the recent articles are: Cattell, *Ueber die Zeit der Erkennung und Benennung von Schriftzeichen, Bildern und Farben*, *Philos. Stud.*, II., p. 635, *Ueber die Trägheit der Netzhaut und des Sehcentrums*, *id.*, III., p. 94; Sanford, *Relative Legibility of Small Letters*, *Amer. Jour. Psych.*, I., p. 402; Griffing, *Visual Perception and Attention*, *Amer. Jour. Psych.* VII., p. 227; Griffing and Franz, *On Conditions of Fatigue in Reading*, *Psych. Rev.*, III., p. 513.

[2] A study from the psychological laboratory of the University of Wisconsin, undertaken at the suggestion of Professor Jastrow, and pursued under his sympathetic direction.

Rate of reading is the main problem, and an endeavor has been made to gain an initial understanding of some of its factors. Visual perception is first studied, with color, form and words (§ II.). Eye and ear are then compared as avenues of knowledge (§ III.), and with these another form of mental tendency is discussed; namely, motor-mindedness (§ IV.). In this connection lip-movement in silent reading is considered. Other sensory and intellectual factors are investigated as possible influences in reading (§ V.). All these are correlated graphically with reading rates, with a view to the discovery of their interrelations.

§ II. Visual Perception.

1. *Method.*—All normal reading involves visual perception. A series of tests was therefore made to determine the quickness of the perception of words, both isolated and in construction, and, by way of comparison, the perception also of form and of color.

The forms used were the circle, square, diamond, vertical and horizontal oblong, hexagon and crescent. These, in gray on a white background, were arranged in two lines on a card, which was placed before the circular opening of an exposure apparatus. On each card were twelve forms, in chance order, presenting an appearance as in figure 1, which shows the exact size.

The subject was required to name *aloud*, *in order*, and *as rapidly as possible*, these geometrical forms, as many as he was able to see while the card was exposed to view for a definite length of time (½″ and 1″). The card was shown repeatedly, until all the forms were read, the subject beginning to read at each exposure where he ended in the preceding.

For colors the method was similar. Colored discs of red, orange, yellow, green, blue, brown, black and white, of 14 mm. diameter, were shown on a gray card, the order as before being determined by chance. So with isolated words, those employed being words in common use, usually of but one syllable. For continuous reading, selections of 15 and 30 words in length were taken from a child's first reader ('great primmer' type).

2. *Apparatus.*—Great difficulty was found in devising an exposure apparatus which would give a sufficient range in time lengths, and yet be reasonably exact. The one used was devised by Professor Jastrow, and gives durations which are uniform within 0.02″, as measured by the Hipp chronoscope. The mechanical principle of it is simple and will be understood from the cut.

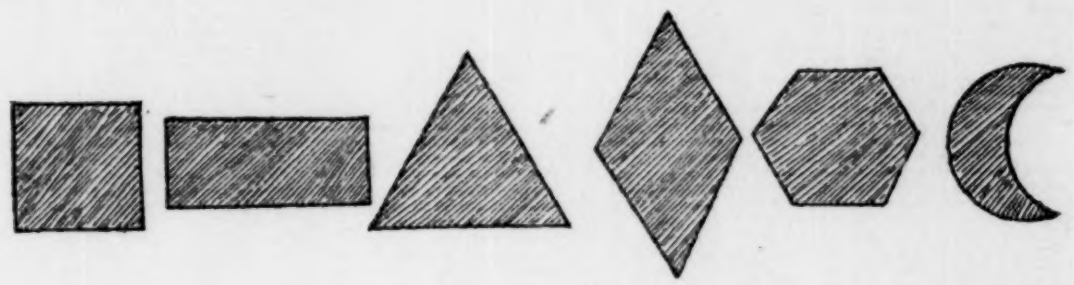


FIG. 1.

To a frame *fr* are attached two shutters, *s*, *s′*, which revolve about a centre pivot *c*. Around this a cord is coiled from which a weight *w* is suspended so as to swing free of the frame. This weight causes the shutters to revolve in the direction indicated, as soon as *s* is released from the catch *d*. *s* is the opening shutter, *s′* the closing one. When the catch is drawn back, the two shutters move around at the same rate (being clamped together at *m*) until *s′* reaches the position from which *s* started, the card being exposed to view during this time. The shutters move at an almost uniform rate of speed, as the short ends are weighted so that each shutter is in

equilibrium in any position when *w* is removed. *p* is a small pin in one of the shutters, beneath which the cord passes—a

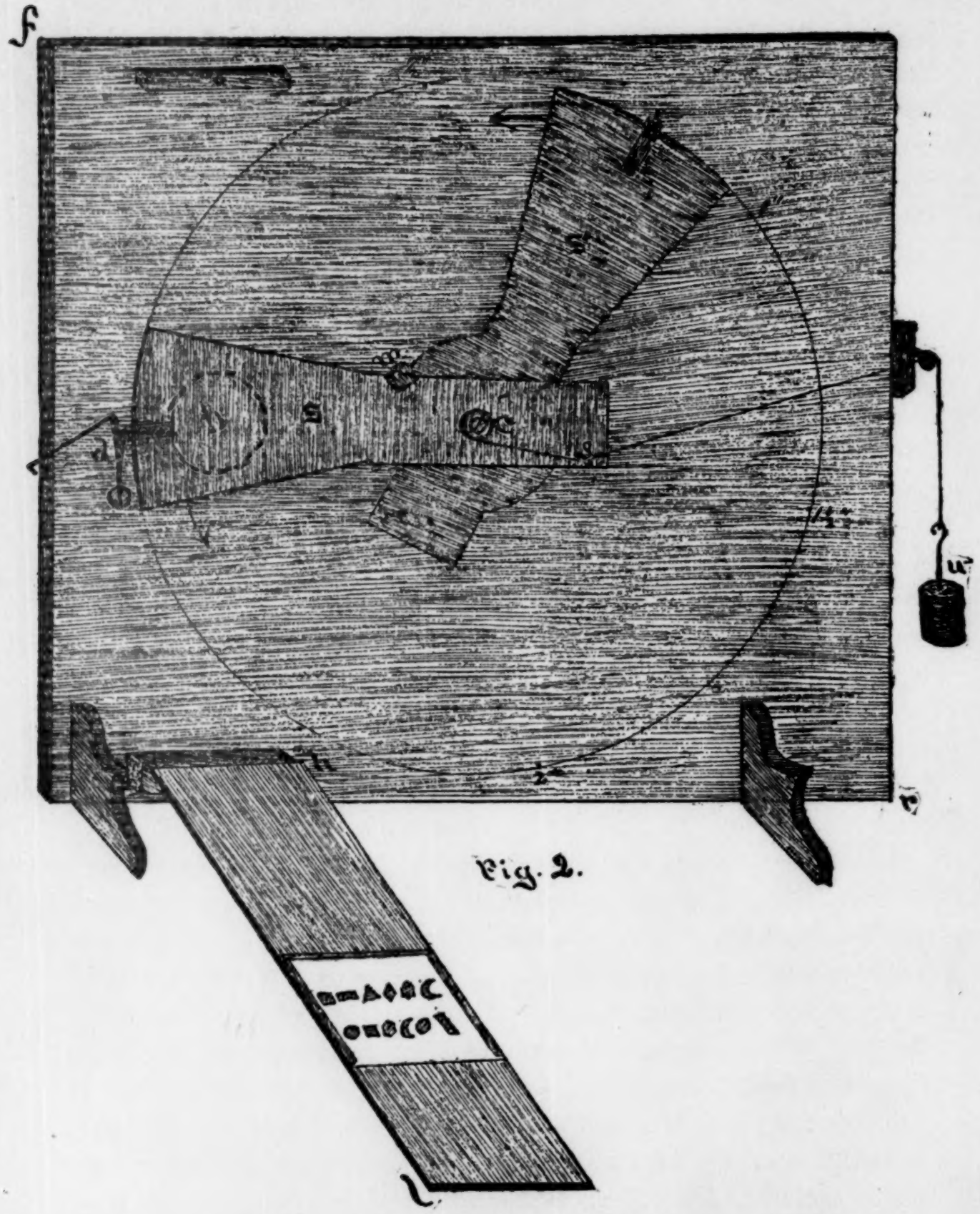


Fig. 2.

simple device for overcoming inertia in starting. The card is placed in a holder *hl*, hinged at the bottom, to allow the cards to be exchanged easily and also removed from before the open-

ing while the shutters are being readjusted. In the cut the holder is shown let down; when brought into position it places the card directly before the circular opening, which is 136 mm. in diameter. The subject is seated at a convenient reading distance in front of the apparatus, the rear view of which is shown by the cut, the mechanism being thus concealed from him by the upright frame. His view of the card is cut off by the shutters except during the time s' requires to pass to the original position of s. This time is proportional to the angle which the shutters make with each other. Consequently different exposure lengths are obtained by changing the relative positions of s and s', regulated by the screw at c; that is, while s remains in the position in which it is held by the catch d, s' is switched around and set at $\frac{1}{2}''$ when a half second exposure is required, and so on for the other lengths. These graduations were originally determined with the chronoscope.

The observer accommodates his eye for the distance of the shutter before it opens, and the card is so close behind this that when seen it requires no re-adjustment of the lens nor change in convergence.

3. *Results and Interpretations.*—The results of the visual perception tests, with fifty university students, juniors and seniors, are given in Table I., which shows not only the relative legibility of forms, colors, words and sentences, but also the relative advantage, in point of speed, of different exposure times. The figures are given on the basis of the number of forms, colors, etc., read per second, and are thus comparable as they stand.

TABLE I.

LENGTH OF EXPOSURE.	FORM.	COLOR.	WORD.	SENTENCE.	AVERAGE.
0.5″	5.5	5.7	7.2	9.9	7.1
1″	2.8	3.5	5.2	8.8	5.1
2″				6.8	
Average	4.2	4.6	6.2	9.4[1]	6.1

[1] The 2″ test (6.8 words per second) is omitted from this average so as to make the sentences directly comparable with forms, colors and isolated words.

Half a second is seen to be relatively much more advantageous than one second (as 7.1 to 5.1, or a gain of 39%), and one second than two seconds (29%).

The shorter time is relatively more favorable because of (*a*) positive after-images, (*b*) primary memory images, and (*c*) less overlapping of mental processes.

(*a*) The positive after-image of the objects seen last persists for a short time after the closing of the shutter, and for the same time *absolutely* no matter what the exposure length may be. Consequently it increases the time *relatively* more in the shorter exposures than in the longer.

(*b*) The memory after-image, sometimes pretty clearly defined, seems to flit before the eye, after the disappearance of the object itself, only waning after several seconds. This amounts practically to a lengthening of the observation time, though the vividness of the object is of course diminished. The gain thus introduced would be relatively greater for the shorter exposures, as all the objects actually seen could be held in the image-complex, but not so with the longer exposures.

(*c*) The shorter exposure-times have an advantage, moreover, in that the different processes do not retard one another by overlapping so much as when the times are longer. The impression made on the retina requires some time to reach the sight center, and become a sensation. But the sensation may be interpreted, that is, may become a perception, after further stimuli are cut off by the closing of the exposure apparatus. The association between object and name may also be formed later, and the motor processes involved in naming be carried out. Thus the various physiological and mental processes are not required to overlap to the same extent in short exposures as in longer, where the form, color, etc., must be distinguished and named while additional sensations are being received. The shorter exposures really include, therefore, for the interpretation and naming of the sensations, a certain length of unreckoned time in addition to the actual exposure-time. The distinction- and choice-time required for discriminating and naming geometrical forms, words, and colors, is certainly not insignificant. The reaction-time for short English words, according to Cattell, is 0.409″,

and for colors (in a group of ten) 0.601″. Deducting 0.170″ as the simple reaction-time for sight, we have left, for the purely mental processes of distinction and choice, 0.239″ for words, and 0.431″ for colors. For geometrical figures this fraction would be larger, as these are read more slowly than either colors or words. The fact that they are so read, and that the difference between the 0.5″ and 1″ rate is much larger than in colors or words, goes to show that the last factor named, the overlapping of processes, is important.

The supposition that these factors do enter is further strengthened by the fact that continuous silent reading at the highest rate of speed at which one is able to read intelligently, under ordinary conditions, is much less rapid than under the special conditions of this experiment. The average maximum rate of all students was 6 words per second in continuous reading, as compared with 8.5, the average of the 0.5″, 1″ and 2″ exposures.

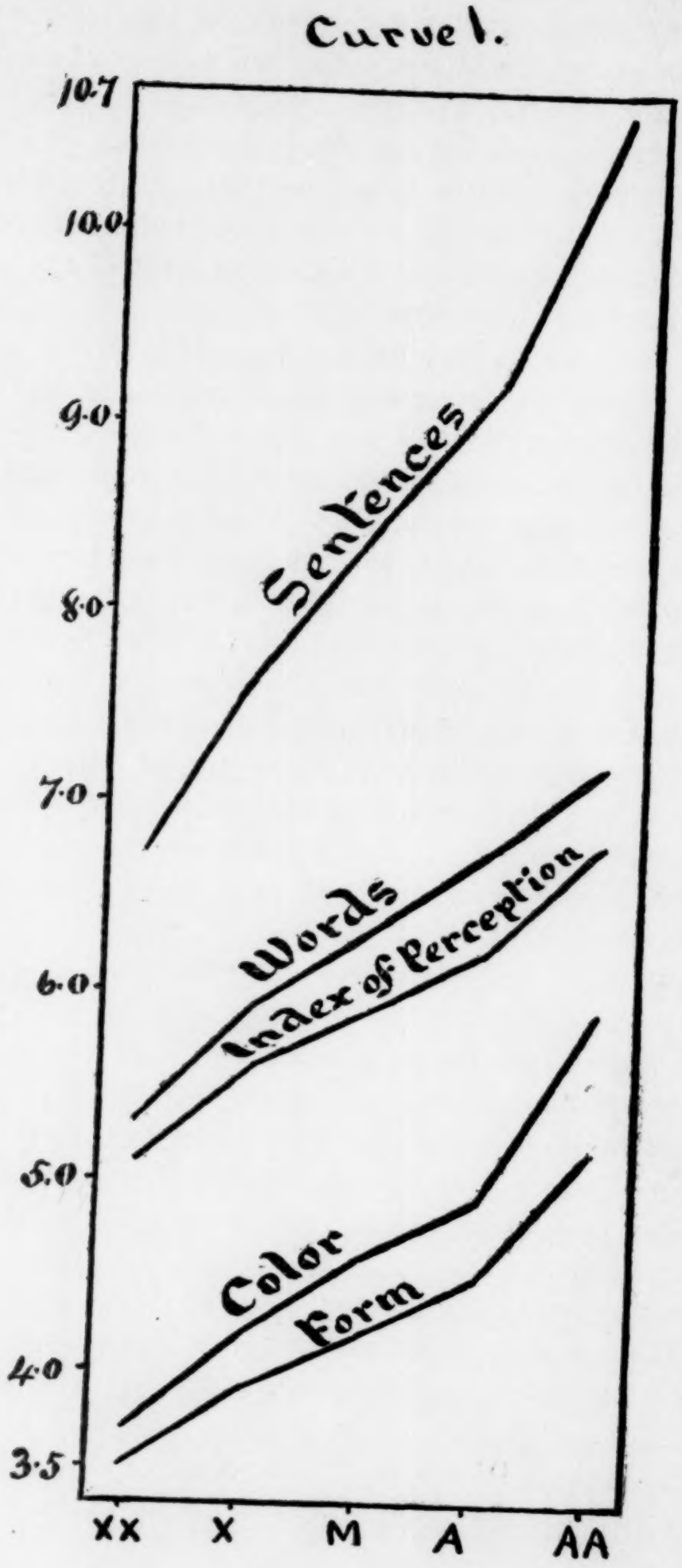
Turning again to the foregoing table we find that colors are perceived and named more rapidly than simple geometrical forms (as 4.6 to 4.2, or an advantage of nearly 10%); isolated words more rapidly than colors (6.2 to 4.6, or a gain of 35%); and words in construction than words detached (9.4 to 6.2, or a gain of over one-half). The relative perceptibility of these classes of things can best be shown by a comparison curve.

The numerals at the side indicate the number read per second. The letters below designate the classes, *XX* being very slow, *X* slow, *M* medium, *A* rapid, and *AA* very rapid. The groups contain approximately equal numbers of individuals; but they are not the same individuals throughout, that is, the *M*'s, for example, of form are not in all cases the same persons as the *M*'s of words, since those individuals who perceive forms with medium quickness may fall into a different class in regard to reading words.

Curve 1 shows:

(1) That forms, colors, isolated words and words in construction are in ascending order in the rapidity with which they are perceived.

(2) That there is less difference between the rates of form and color (the curves lying closer together) than between the others.


Curve 1.
10.7
10.0
9.0
8.0
7.0
6.0
5.0
4.0
3.5
Sentences
Words
Index of Perception
Color
Form
XX
X
M
A
AA

(3) That there is less difference between the slowest (*XX*) class in the different types of perception than between the most rapid (*AA*), except in the relation of color and words (the lower ends of the lines are not so widely separated as are the upper ends.) Those who are poor perceivers show a narrower range between the different types of perception than do those who are good perceivers; that is, for them the different kinds of perception are less differentiated. Consequently

(4) That there is more variation in rapidity between the most rapid and the slowest in sentence reading than in the other tests, and slightly more in color than in form or in words (the sentence curve is the longest).

(5) There is more difference between the 'good' and the 'very good' than between any other two groups (the part of the curves connecting *A* and *AA* tends upward more than any other part). This is the common observation that those who are exceptional in anything are farther removed from the merely 'good' than these latter are from the average.

(6) The curves are very similar, which means that many of the same factors enter into the perception of forms, words and sentences. That the curves have the same general tendency but are not absolutely similar shows that these influencing factors enter in varying degrees into the perception of the different sorts of objects.

The 'index of perception' is formed from averages of all the types of experiment (the average being formed not from groups, but from individuals, thus making it more exact), and therefore lies between the other curves. It represents the general perceptive power of the different groups.

The large difference in the rate of perception in the different types is due mainly to association. The association between the written and spoken word is much better established because much more frequently formed than is that between the geometrical figure and its name. It is moreover more definite. In adult life we 'intuit' a word as a whole (at least in the case of short familiar words, such as were used throughout these tests), but the combination of characters forming it has a definite meaning; whereas the forms may be designated by different names.

For example, ◇ is called a diamond or a rhombus, ○ circle or globe, ☾ moon or crescent. This is returning to the indefiniteness of primitive picture-writing as compared with the highly evolved phonographic language.

The association is of the same sort in words as in forms or colors, for the connection between the written symbols and the spoken sound of any given word is just as arbitrary as is that between a particular geometrical form and its name as uttered. But the association between forms or colors and their names, being less necessary than between written and printed words, has been less frequently formed and the former has remained a voluntary process while the latter has become automatic through repetition. That the strength of an association is measured by the time it requires is abundantly illustrated by experiments in complex reaction-times; for example, the times required to name a picture in the vernacular and in a tolerably familiar foreign language were 0.477″ and 0.649″ respectively.[1]

The same explanation applies to colors: the association between color and name is closer than that between form and name, but not so well established as between written and spoken word (0.409″ for words, 0.601″ for colors, are the reaction-times, as already given). In the continuous reading, moreover, the thought introduces a thread of connection between the succeeding words, and thus a readjustment of attention in passing from one word to another is not required. The reaction-time for words in construction is 0.138″, which is much less than for disconnected words.

No. 2 is a distribution curve. It is formed, therefore, not by putting an equal number of individuals into each group, but by making equal absolute differences between the number of words, etc., read per second by the different groups—that is, the range in perceptive power is the same for each group.

Curve 2 shows:

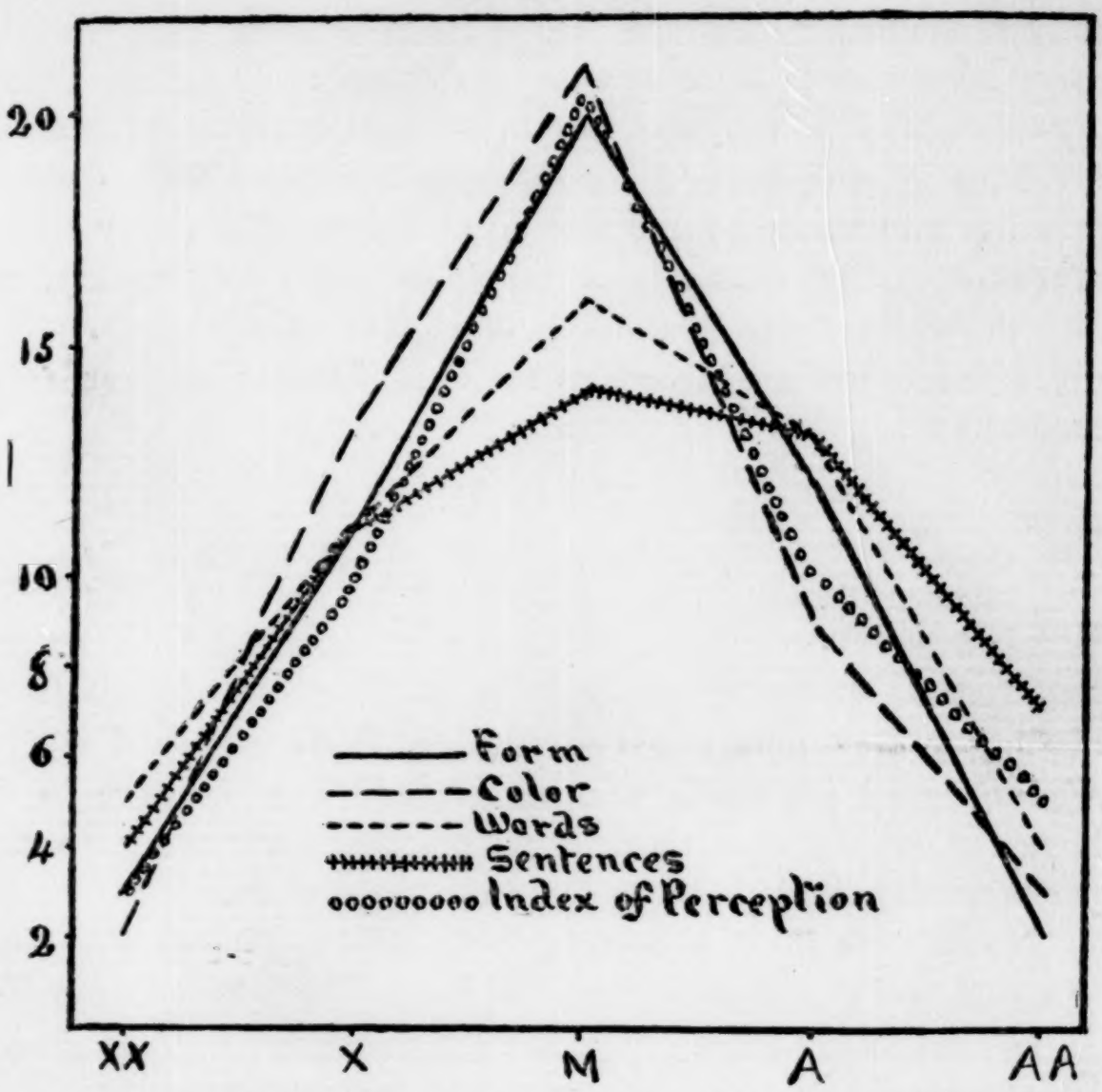
(1) That in visual perception, as in the distribution of individuals according to any other mental or physical test, many cluster around the average point, falling off gradually in both directions measured by equal absolute differences, there being

[1] Jastrow: *Time Relations of Mental Phenomena*, which see for examples illustrating this principle.

relatively few who are either exceptionally good or humiliatingly poor. The probability is high that an untried specimen will be found to be near the average.

(2) That the number of persons represented in any class decreases at about the same rate above and below the average. (The curves are tolerably symmetrical.)

Curve 2



(3) That in the reading of isolated words and of sentences the number of persons who are near the average is comparatively fewer (apices of curves are not so high); that is, individuals are relatively more like one another as regards their capacity to read forms and colors—the less familiar processes.

4. *Correlations.*—In addition to comparison and distribution curves we shall have occasion to use what are known as 'correlation curves,' and a brief explanation of these may be

given. If one thing completely determines another, or, in mathematical phrase, if one is a function of another (for example, if quickness or slowness of visual perception is the sole determining factor of increase or decrease in the rate of one's reading), or if two things depend upon identical conditions (for instance, if a subject's maximum rate of intelligent reading is determined by absolutely the same factors as his normal rate), then in both cases the second of these will increase proportionately to the first.[1] The graphic method of illustrating this by correlation curves is somewhat as follows[2]: Dividing all the persons tested into groups, say 5, with an equal number of individuals in each group,[3] according to their *maximum* speed of reading, and naming these classes, as before, *XX* (very slow), *X* (slow), *M* (medium), *A* (rapid), *AA* (very rapid), we find the *normal* rate of reading of each of these classes. This gives the following table expressed in number of words per second.

TABLE II.

Classes	XX	X	M	A	AA
Maximum Rate	4.3	5.2	5.7	6.5	8.7
Normal Rate	3.8	4.4	4.6	5.6	7.0

That is, when the principle of division into classes is according to maximum speed of reading, those who read at their *highest* speed 4.3 words per second, and are therefore in the lowest class, are able to read at their *ordinary* rate 3.8 words per second. And similarly for the other classes.

Now, if we take a rectangular surface divided into small squares, and graduate one side of it (horizontal) with numbers

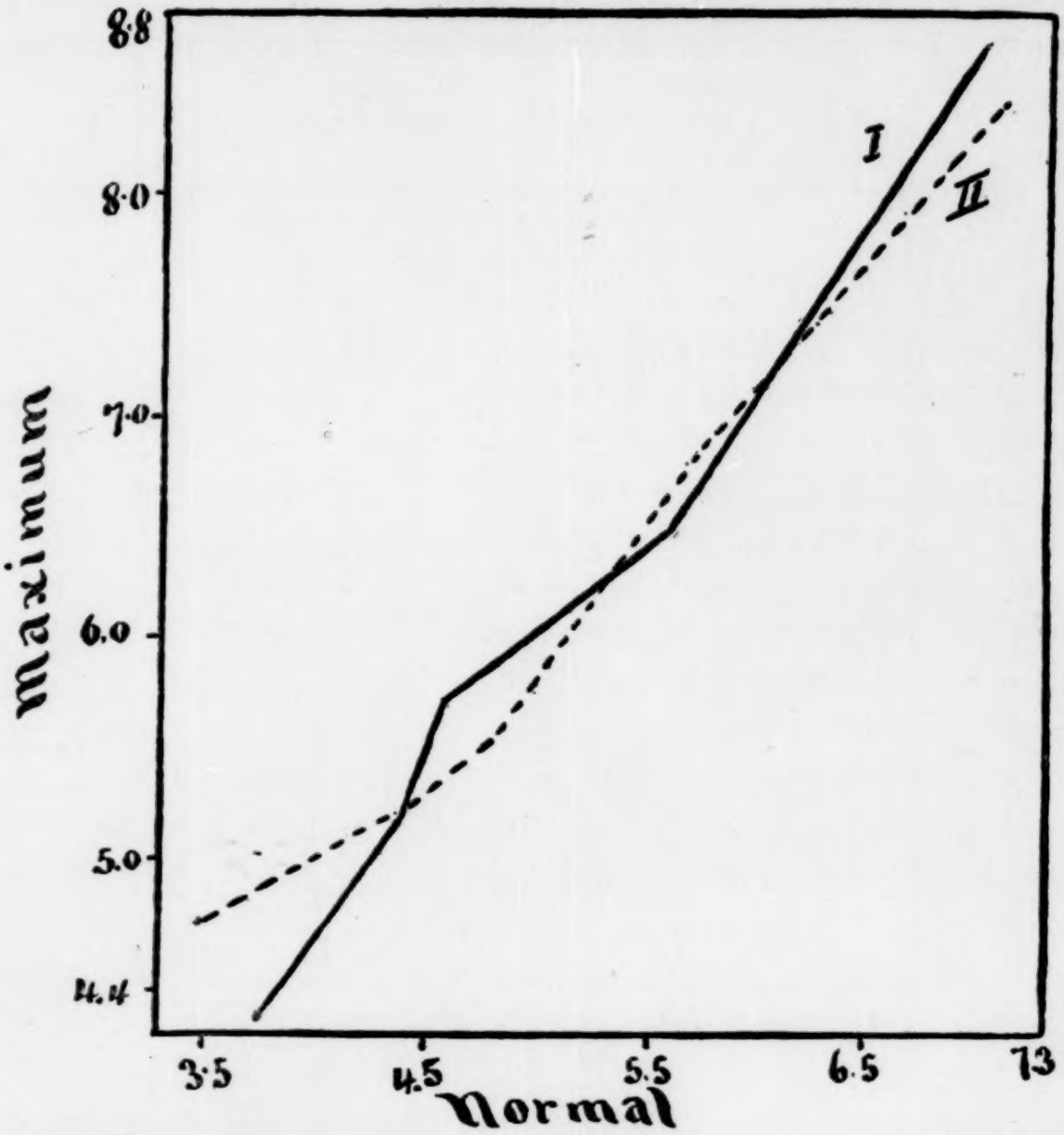
[1] It will perhaps be said that Weber's law contradicts this; external stimulus is the cause of sensation, but a vibration of air of intensity $2x$ will not cause twice as loud a sound as a vibration of intensity x. But it is to be remembered that external stimulus is not the sole cause of sensation. Physiological conditions must be included.

[2] See article by Dr. Franz Boas on Correlation in *American Anthropologist*, July, 1894.

[3] Equal *differences* in rate between the groups, or any equal *range* of variation in each might be chosen as the standard of division, instead of equal *numbers* in each group; but the latter method is employed throughout this research as being more suitable where the whole number of individuals is not large.

representing *normal* reading rates, and an adjacent side (vertical) with numbers which correspond to *maximum* reading rates, we can find a point in this rectangle whose horizontal position is represented by 3.8 and vertical by 4.3—the numbers designating respectively the normal and maximum rates of those readers who are 'very slow' when classed according to their maximum rates. Similarly points may be found for each

Curve 3.



of the other classes. Connecting these points gives a line (I. in curve 3) which we may designate the 'curve of normal reading rate as determined by maximum rate.'

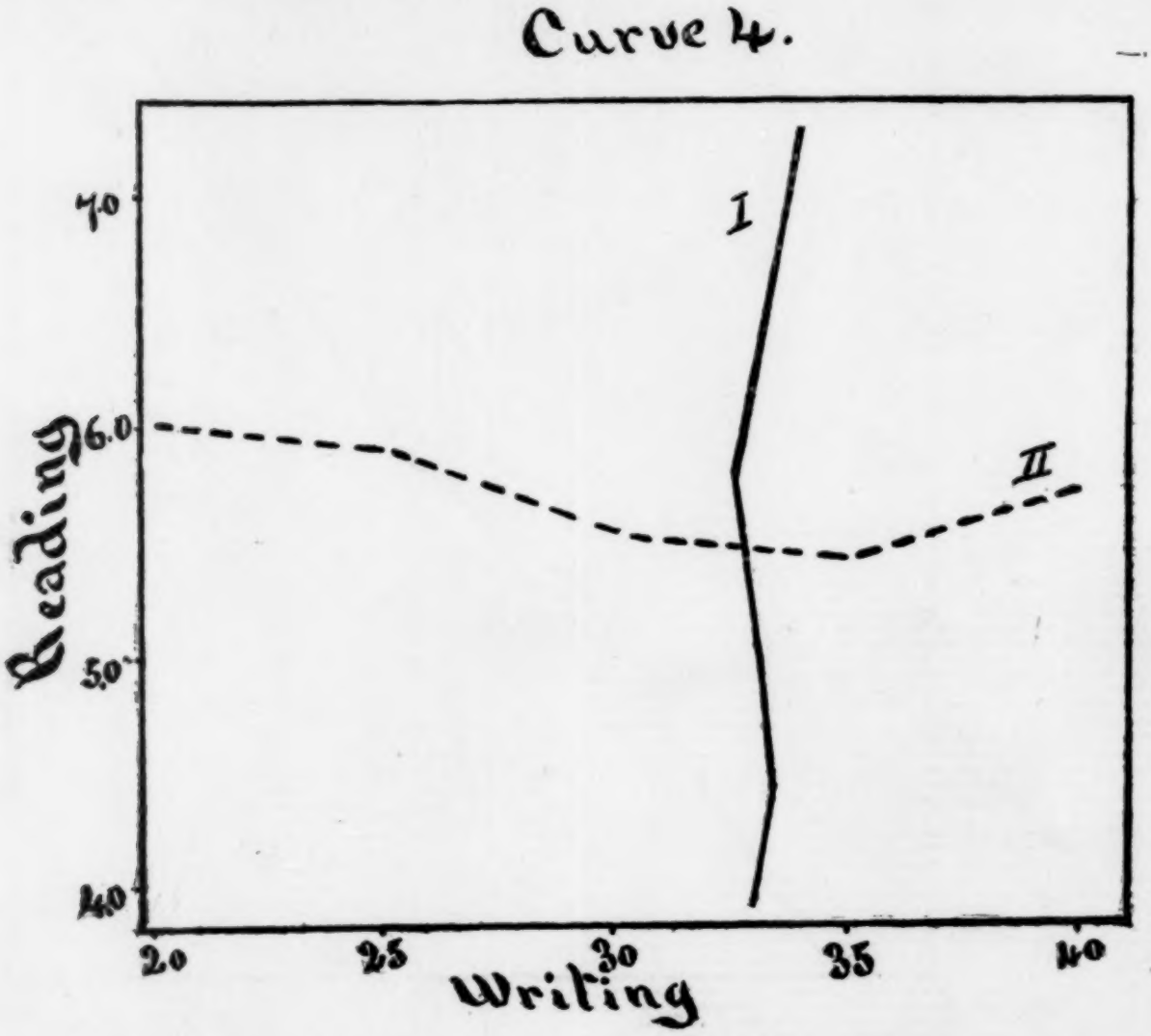
Further, we may group these individuals into classes determined by their *normal* reading rates, and find the average

maximum rate of these classes, thus obtaining the following table, which gives a second curve, namely, 'maximum reading rate determined by normal.'

TABLE III.

Class	XX	X	M	A	AA
Normal rate	3·5	4·3	4·8	5·8	7·1
Maximum rate	4·7	5·1	5·5	6.8	8.4

This completes the correlation and shows at a glance how closely related maximum and normal reading are; that is, how nearly the same forces determine both. If the two phenomena



were determined throughout by the same factors, and to the same extent, the curves would exactly coincide on the diagonal of the rectangle. If the influences operative in both were largely, but not entirely, the same the curves would have the same general direction, but would cross near the middle and diverge slightly toward the ends (see Curve 5). The fewer the common factors

the wider would be the divergence (cf. Curve 4 with 5), until when the two progressions under consideration were absolutely independent of each other the 'curves' representing them would be straight lines crossing at right angles—provided always the number of records included in the calculation was sufficiently large to eliminate the influence of accidental variations. For example, if we were to correlate speed of mechanical writing with reading rate and find the classes to be as follows:

TABLE IV.

WRITING DETERMINED BY READING (I.).

Classes	XX	X	M	A	AA
Reading	3·9	4·4	4·9	5·8	7·3
Writing	33	33·5	33·2	32·5	34

READING DETERMINED BY WRITING (II.).

Writing	20	25	30	35	40
Reading	6.0	5·9	5·5	5·4	5·7

It would mean that the rates of reading and of writing were practically independent of each other, as shown by curve 4.

As the rate of reading advances through the several classes from slowest to most rapid, the speed of writing, being uninfluenced by that of reading, remains with almost the same average in each class throughout. Thus the curve of 'writing determined by reading' (I.) is vertical, not tending far to right or left. Similarly the curve of 'reading determined by writing' (II.), where the individuals are grouped according to rates of writing, advances horizontally, not deviating to any great extent either up or down, since the different rates of writing all correspond to the same reading rate. This, then, shows that reading and writing rates are almost independent of each other.

Further, if some of the influences which produced greater speed in writing were actual hindrances to rapidity of reading, and *vice versa*, the curves would revolve still farther in opposite directions; that is, they would again approach each other, but in this case the 'upper ends' of the curves, representing the highest rates, would lie toward opposite ends of the diagonal of the rectangle (see Curve 11). This approach would continue as the determining elements became more antagonistic, until, when the factors which produced speed in the one process

were exactly the same which caused slowness in the other,—that is, when the determining influences were entirely incompatible with one another,—the curves would again coincide, the beginning of one falling upon the end of the other, and *vice versa*. Through this general explanation the correlations which follow will be easily understood.

The figures connecting visual perception and reading rate[1] are as follows:

TABLE V.

VISUAL PERCEPTION DETERMINED BY READING RATE (I.).

Classes	XX	X	M	A	AA
Rate	3.9	4.4	4.9	5.8	7.3
Perception	5.35	5.7	6.05	6.3	6.3

READING RATE BY VISUAL PERCEPTION.

Perception	5 06	5.64	5.92	6.17	6.77
Rate	4.22	4.59	5.31	5.42	6.62

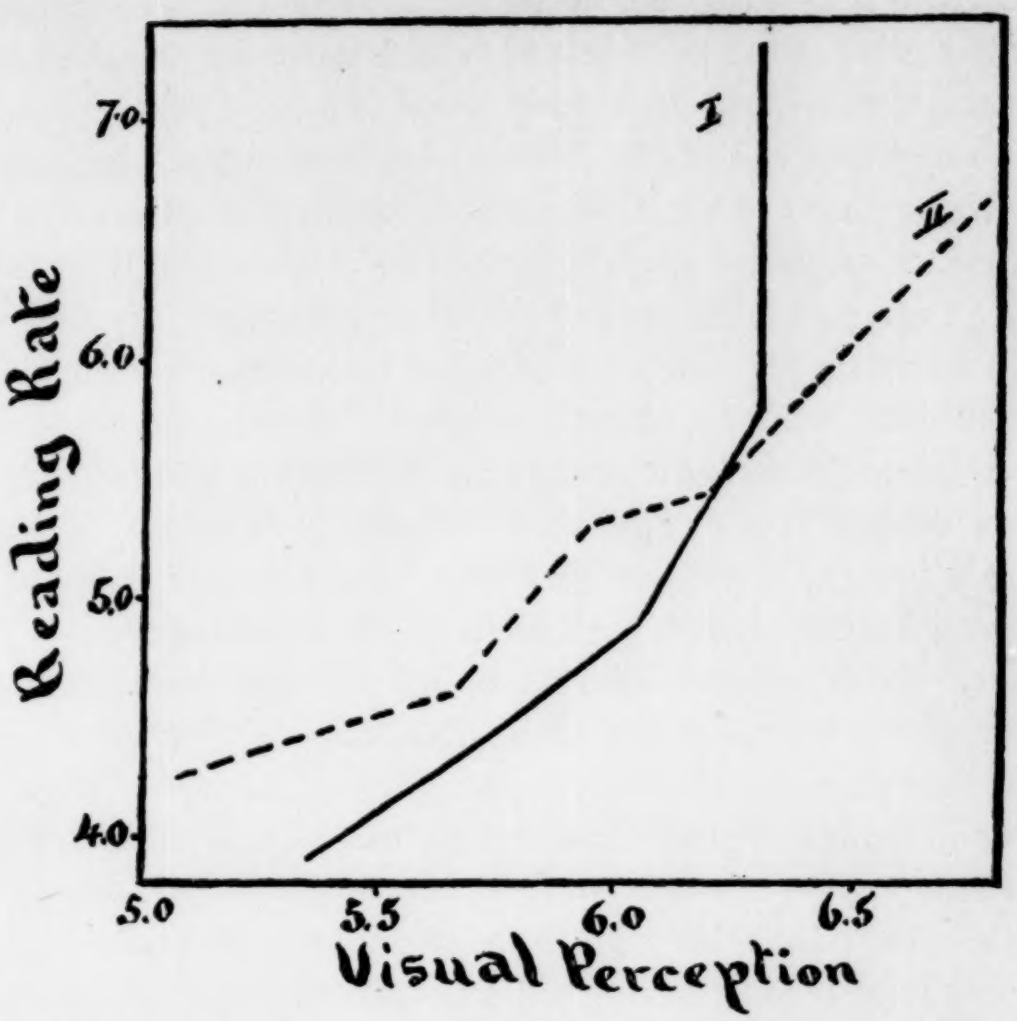
By this method of representation, therefore, the relation of visual perception to reading rate is shown by curve 5.

This shows that mere quickness of perception, with its large physiological element, is an important factor in deciding one's rate of reading, as the lines of curve 5 are far from being perpendicular to each other. That they are also far from coinciding leaves room for other large factors in the determination of speed of reading, as the sequel will show.

The number and the nature of the errors made in the visual perception tests deserve, perhaps, a word of comment. Out of a possible 48 the average number of errors was, for form 1.4, color 2.7, words 0.5, sentences 0.6. Inversions of order and omissions are common throughout; but substitutions, of course, occur with far greater frequency. Hexagons are often mistaken for circles, these two figures resembling each other more closely than any of the others used in the tests. Most errors are made, as one might expect, in the naming of

[1] The index of 'visual perception' was obtained by taking the average of forms, colors, words in isolation and in construction. 'Reading rate' here, and as used throughout, unless otherwise stated, is the average of the maximum rate under ordinary conditions and the normal rate of both the long and the short selections of silent reading. Reading aloud is not included as it does not show individual differences as silent reading does; *e. g.*, in silent reading the variation is all the way from 3.3 to 12.2 words per second for maximum rates, and 3.5 to 8.8 for normal; while in reading aloud the differences are within a range of 2.6 to 3.9 for normal rates.

Curve 5.



colors. This may, to some extent, be accounted for on the supposition that some subjects, especially men, misname a color even when seeing it correctly. An effort was made to eliminate this source of error. Whenever it was suspected the subject was tested by means of color cards not used in the perception experiments. Before the color experiments were made, moreover, the subject was shown all the colors that he would be required to name, and his color designations corrected when in error. Notwithstanding these precautions errors were comparatively frequent. Orange was mistaken for yellow 29 times (by all subjects in the whole series of experiments), and yellow for orange, twice; orange is called red 20 times and red orange four times; blue is called green four times, and green blue ten; red is said to be brown 16 times, and brown red, twice. When seen by a momentary glance, therefore, colors are very liable to be mistaken for one another, and the uniformity of this error seems to follow the rule that adjacent colors of the solar spectrum are most likely to be confused—orange with red or yellow, green with blue, etc.

The errors in the perception of words were less numerous. In reading isolated words the substitutions were of those similar in appearance, while in sentence reading the substitutions were of words similar in sense. These errors are not due to mere guessing; the subject 'sees' what he reads, as has been noted by other observers.

§ III. Sensory Types.

1. *Methods of comparison between eye and ear.*—Dismissing for the present the tests in which the eye alone was employed as the receptive organ, we may proceed to a class of experiments in which eye and ear are both involved, and institute a comparison between these in their powers of acquisition and retention. Considering language only, is the eye or the ear a better medium for the gaining of knowledge? It is a pedagogical question of no little importance. In view of what has already been written on the subject[1] we may at once answer: Some persons are ear-minded—they think most readily in auditory ('phonographic') images; others are eye-minded, thinking in visual ('photographic') images;[2] while a probably much larger number are fairly well balanced, using either process indifferently, or both together. Our present interest being only in the relative advantage of the visual or the aural bias, our specific question becomes: Are persons who are distinctively of the visual type more rapid or more intelligent readers than those of the auditory type, or less so?

The comparison between eye and ear was made in three ways: (1) by testing the visual and auditory span; that is, the limit of power to repeat correctly words read or heard once; (2) by detection of differences between two variant readings of the same passage; (3) by the ability to reproduce the thoughts of two selections, one of which was read to the subject, the other read silently by him *at the same time.*

2. *Memory Span Test.*—In testing the 'span of prehension' (as it has been called[3] from its analogy to apprehension and comprehension, to both of which it is related as a simpler process), short one-syllabled substantives were used, of four, five

[1] Jastrow: *Eye-mindedness and ear-mindedness*, Pop. Sci. Mo., Vol. XXXIII., p. 597, from which the following methods are borrowed in substance; Egger, *La Parole intérieure;* Galton, *Inquiries into Human Faculty*, etc.

[2] "Certaines personnes sont plus sensibles à l'excitation esthétique ou intellectuelle quand elle se présente sous la forme d'un tableau et passe par les yeux, d'autres quand elle s'incarne dans une symphonie et arrive à l'esprit par les oreilles. Ce sont ces excitations-là qu' elles rechercheront. Les créateurs se serviront aussi de ces formes concrètes pour exprimer, pour dépenser leurs propres émotions." Paulhan, *Les Caractères*, p. 123.

[3] Joseph Jacobs, *Mind*, XII., p. 75.

or six letters, as being less confusing and less variable in their relative difficulty than nonsense-syllables, and more closely allied to the sort of memory we continually exercise.[1]

It is doubtless true that eye- and ear-mindedness should be subdivided. One person, for example, remembers forms most easily, another colors; memory is to be resolved into memories; yet the general types, visual and auditory, are sufficiently well marked.

The tests on which the comparison is based were of three kinds:

(*a*) Auditory, in which the words were read *aloud to the subject*, at a rate deemed the most favorable, about one hundred per minute.

(*b*) Visual, in which the printed words were read *silently by the subject*, at the same rate as before.

(*c*) Visual and auditory combined, in which the lists of words were read *aloud by the subject*, thus giving him the advantage of both eye and ear as receptive organs.

In each case beginning with four, the number of words read to the subject or by him was gradually increased to the limit of his capacity for repeating the words with absolute correctness—the correct words and in the right order—the words being reproduced without any interval after the reading of each list. Rhythmic grouping of words in reading was avoided. A marked tendency to group into 3's had especially to be guarded against.[2] Ebbinghaus[3] found that memory span was considerably greater when the material to be repeated was grouped than when given at a uniform rate throughout. There is a possible analogy between successive rhythmic grouping of words read and simultaneous visual grouping which increases the extensive limit of intuition.

The average of all subjects was: Auditory span of prehension, 5.7 words; visual, 5.5; auditory and visual combined,

[1] The kind of material used, however, was not important, as our interest was not in the *absolute span*, but in the *relative span* between eye and ear.

[2] For the rhythmic tendency in general see T. L. Bolton, *Rhythm*, *Amer. Jour. Psych.*, Vol. VI., No. 2. He finds that 3 is an unfavorable group; but his 'clicks' were much more rapid than the reading of words. Consequently a larger number in the group would be more common.

[3] *Das Gedächtniss.*

6.3. The number of letters repeated is slightly larger, and numerals exceed these considerably, probably because our attention has to search among only 9 numerals but 25 letters (omitting 'double *u*'), and because we are accustomed 'to take letters in groups having a phonetic value, but numerals have few if any associations of contiguity; we find them in haphazard order."[1]

More difference was to be expected than is found between the single process of eye or ear alone, and the double process of eye and ear reinforcing each other. Those who are decidedly auditory or visual are not able to do much more creditably by the help of both eye and ear than by their favorite single process of either vision or audition. Actual results show indeed that so far from the addition of a second sensory process being any advantage for individuals who are distinctively of one type, it is in many cases an actual hindrance. This would mean that in the case of decided 'visionaires,' or 'auditaires' the simultaneous use of a second sensory avenue interferes with the concentration of attention upon the sensations received through the primary.

Correlated according to this memory-span test the eye-minded student is a more rapid reader than the ear-minded, though the difference is not striking. The numbers of Table VI express the visual-auditory ratio in percentages; that is, they show what per cent. the visual memory-span is of the auditory. The *XX*'s therefore of 'eye-mindedness' include those subjects who are decidedly of the auditory type, as distinguished from the visual; the *M*'s, those who are balanced between eye and ear; and the *AA*'s, those who are strongly visual.

TABLE VI.

MEMORY SPAN DETERMINED BY READING RATE (I.).

Classes	XX	X	M	A	AA
Rate	3.9	4.4	4.9	5.8	7.3
Span	94.99	93.56	96.2	98.66	101.8

READING RATE BY MEMORY SPAN (II.).

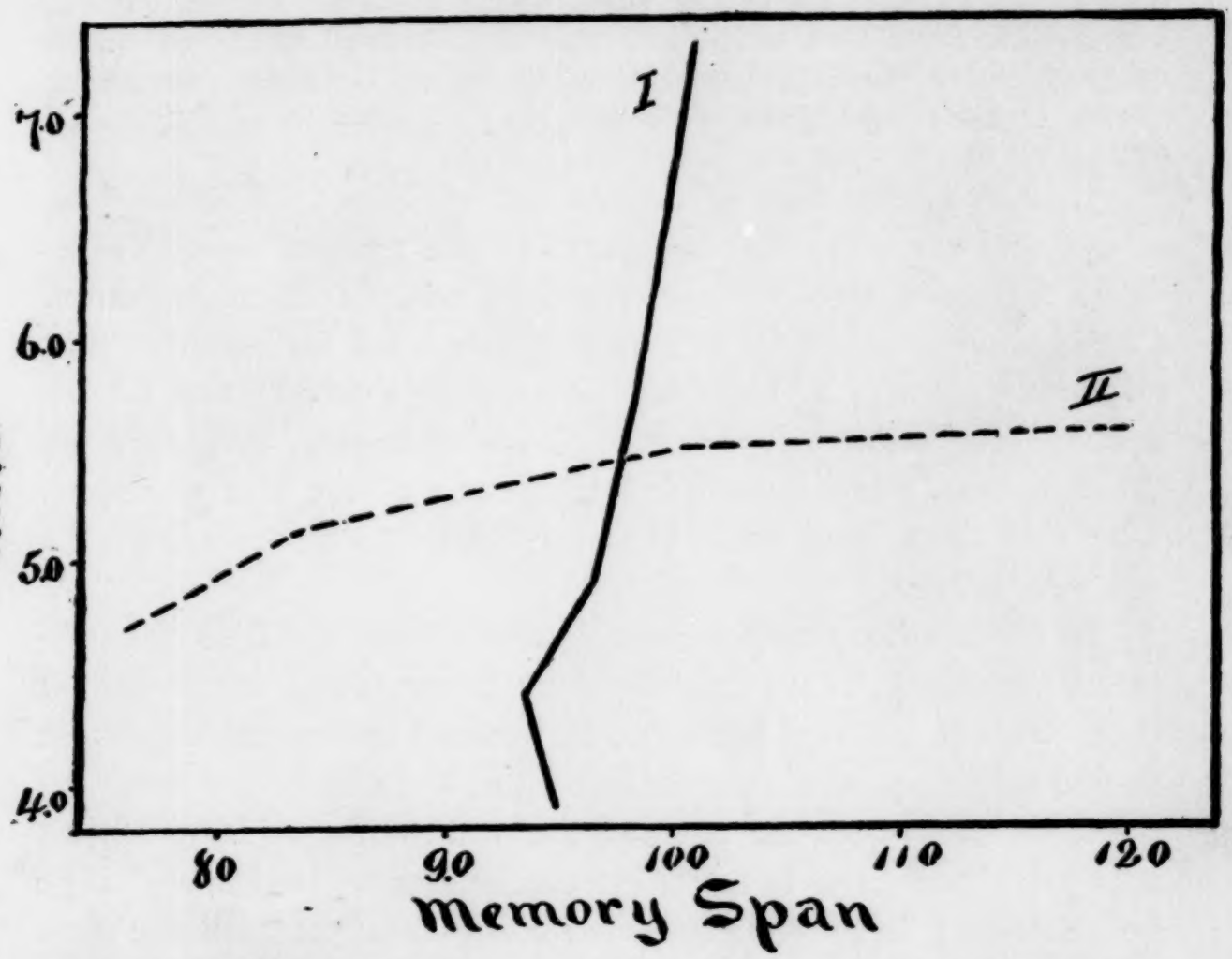
Span	76.8	83.5	100.0	120.5
Rate	4.68	5.16	5.46	5.56

From this the following curve is constructed:

[1] Jacobs, *loc. cit.*

This shows, on the whole, a gradual increase in the rate of reading as the subject moves away from the auditory type and toward the visual. It might be added that slow readers have a lower memory span than rapid. The average total number of words recalled from the auditory, the visual, and the auditory-visual combined test was 16.1 for very slow readers and 20.4 for rapid readers.

Curve 6.



Eye-mindedness is of course quite different from quickness of visual perception. A correlation on the basis of these tests shows absolutely no reciprocal influence.

The errors made in reproducing the lists of words used in this test might furnish material for an interesting chapter in the study of association. Without taking space for details the following deductions might be made: (*a*) Repetitions are frequent—about equally so from the words which are being reproduced and from the list just preceding (in the latter case usually the last word of the group, as that is much more likely to persist). Repetition may be interpreted as a lurking of the memory after-image in the background of conscious-

ness. (*b*) The order is often reversed, as is to be expected from the nature of association. Ebbinghaus and others have shown that the memorizing of a list of words or syllables in a certain order aids in learning it in reversed order: associations are formed backwards. (*c*) In the auditory lists there are many substitutions of a word for two others from which it is compounded phonetically, as 'coal' for 'call' and 'soul,' 'feel' for 'fear' and 'meal.' Variations of this tendency appear in such substitutions as 'deer, foot' for 'door, feet,' and 'race, freight,' for 'rate, phrase.' (*d*) Confusions in sense are less common than those in sound; instances are, 'flour' for 'meal,' 'string' for 'stick.' (*e*) Words are occasionally inserted which have a similarity in meaning to the word which evidently suggests them, being at the same time allied in sound to another of the words used, as 'hay' after 'fork' ('gray' being in the list), 'chain' following 'cord' ('cheer' and 'pain' occurring), 'jest' after 'smile' ('guest' appearing in the same set of words).

3. *Test by detection of differences.*—The second comparison of eye and ear was made by means of the recognition of differences between two variant readings of the same selection. Changes were made by substituting one word for another, usually synonymous; by inserting or omitting a word; and by inverting the order of phrases. Five changes, involving all these classes, were introduced into each of the test passages. The selections used were short—of only 50 words—and of a concrete nature.

In the auditory tests a selection was read aloud to the subject three times in succession (once being found insufficient); then, with no interval between, he listened to the reading of the varied selection once only, being asked to indicate the nature of the differences between this and the first reading. The subject was permitted here to interrupt the reader whenever a change was detected, in order that all the changes might not have to be carried in mind to the end. In the visual series the method was exactly parallel. Instead of hearing the passage read the subject read it himself, silently, three times; then the selection with the necessary changes was given him, and in this he pointed out the variations which he was able to remember. Results are given in percentages in

TABLE VII.

	SUBSTITUTION.	INSERTION.	OMISSION.	INVERSION.	AVERAGE.
Auditory	43.8	96.2	23.6	50.9	53.6
Visual	36.3	67.3	11.3	42.5	39.4
Average	40.1	81.8	17.5	46.7	46.5

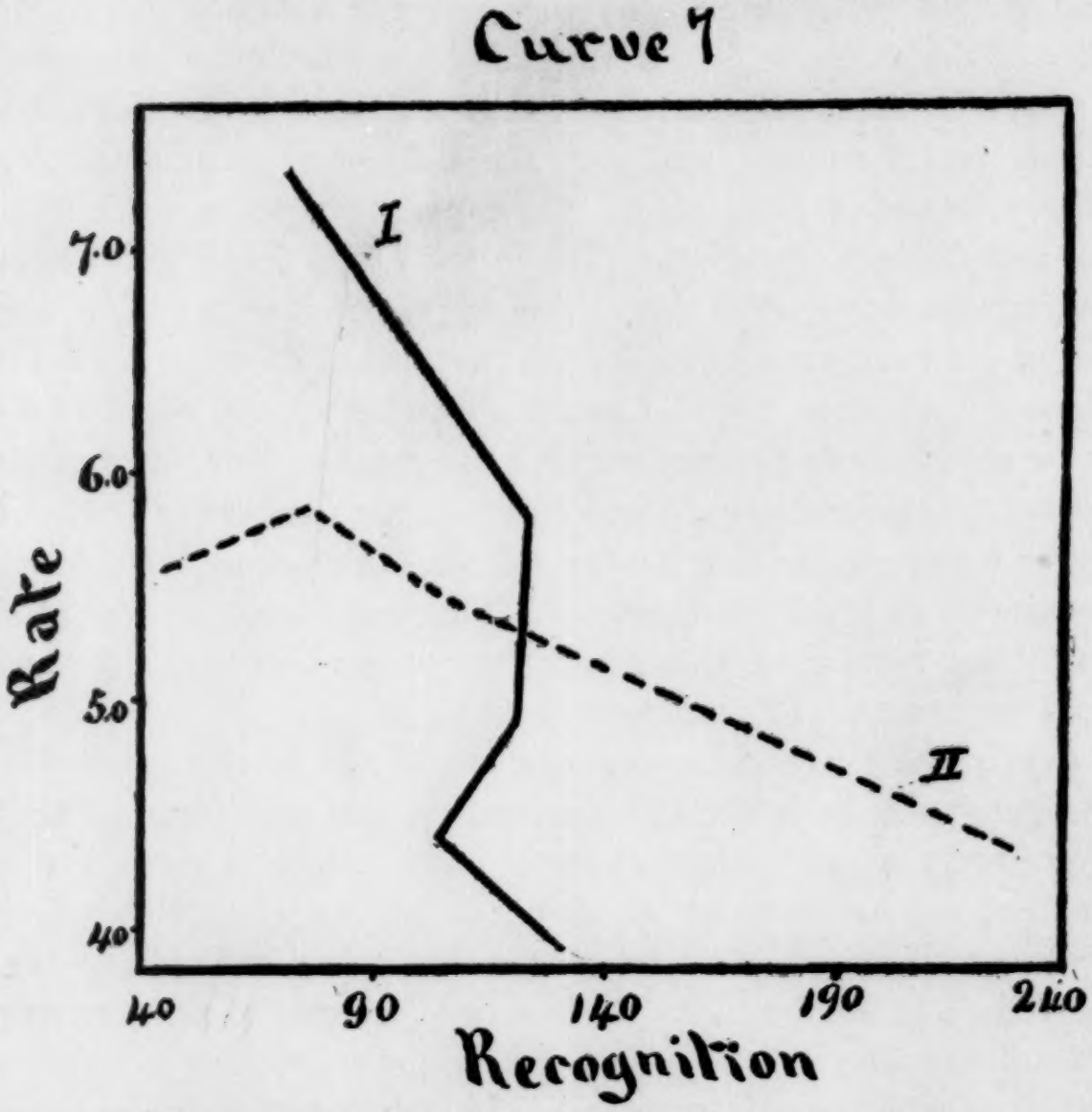
This gives a comparison (*a*) between auditory and visual memory and recognition, (*b*) between the relative recognizability of the different kinds of change made in the passages.

(*a*) Why there should be as great a difference between the auditory and the visual, and with the difference in favor of the auditory, is not at once clear. The passages were read with clear and distinct enunciation, but in the visual tests the subjects were requested to exercise the same degree of care in their silent reading (in each case knowing the purpose of the test). Yet it is doubtful whether they did so; perhaps because in silent reading we are likely to proceed much more rapidly, and, it must be confessed, less carefully. Nevertheless, the result here obtained may be a suggestion that we are not, on the whole, so decidedly eye-minded as has been supposed. This conclusion is supported also by the results of the other comparisons of auditory and visual processes. (Paragraphs 2 and 4.)

(*b*) In the comparison between the kinds of change in the passages it will be noticed that insertions are much more easily recognized than any other change, almost two to one; inversions and substitutions are about equal in the ease with which they are recognized, and omissions are more difficult by far. The reason is not far to seek. If a pen is removed from among half a dozen on our study-table we do not notice the change so readily as when one is supplied. In the latter case the novel object is there to attract our attention; in the former, all we have is a change of relations among the remaining objects, and a new relation is not so easily detected as a new sense perception. Moreover, the subject in these tests was required to tell the exact nature of the change. In the insertions the unfamiliar word was there to be seen and named; in the case of omissions

it had to be recalled. Here, as in the other changes, the *fact* of a difference was often recognized and yet the *nature* of it not known. This may be due to memory-images, the sound dimly vibrating, or the vision of a word indistinctly hovering, in the margin of consciousness. Changes not present were sometimes introduced and somewhat more frequently in the auditory than in the visual tests.

The position, in the selection, of the different changes would have an influence. Those occurring near the beginning or the



end would be more likely to be remembered, as 'primacy' and 'recency' are recognized conditions of suggestibility.[1] The different sorts of change were therefore distributed somewhat evenly throughout the selections. Vividness might also be a factor in the suggestiveness of certain changes; one substitution,

[1] See Miss Calkins on *Association*, a Monograph Supplement to PSYCH. REV., Feb., 1896.

for example, might be more impressive than another. Visual and auditory series, however, were made in every point as nearly comparable as possible.

The comparison of reading rate with the predominance of eye-mindedness gives a result quite different from that obtained by the memory-span test. Here the most rapid readers are those who incline most strongly toward the auditory type, as the table and the curve (7) show.

TABLE VIII.

RECOGNITION OF CHANGE ON THE BASIS OF READING RATE (I.).

Class . .	XX	X	M	A	AA
Rate . . .	3.9	4.4	4.9	5.8	7.3
Change .	130.38	105.01	122.12	122.17	71.66

READING RATE BY RECOGNITION OF CHANGE (II.).

Change .	42.4	77.7	103.37	148.13	227.39
Rate . . .	5.56	5.89	5.47	5.05	4.36

The lines incline more or less towards the N.W.–S.E. diagonal of the rectangle. Eye-mindedness, as determined by this test, is therefore detrimental to rapidity of reading. The interpretation of this is doubtless very simple: rapid reading is not favorable to the detection of slight differences in form or meaning. The rapid reader, acquiring the habit of looking only for essentials and disregarding unimportant details, detects minor variations less readily in written than in spoken sentences. But though rapidity of reading is not conducive to the recognition of differences through the eye alone, yet the sum of the changes recognized by eye and ear is 40% greater for very rapid readers than for the slow.

4. *Method of Comparison by Simultaneous Reading and Hearing.*—Eye and ear were compared lastly by the number of thoughts reproducible from the material acquired through these sensory avenues. Two selections, each of about 150 words, were read simultaneously, the one silently by the subject, the other aloud by the experimenter.

As before, the material used was of a concrete nature and easily picturable, as anything abstract would have been entirely too difficult for a test under such conditions. The subject read

his extract at about the same rate as the other selection was read to him, the ending of the two readings as well as the beginning being thus simultaneous. The subject then repeated as many of the thoughts as he was able to recall of each selection, and, so far as possible, in the same words. A complete record of this was taken in shorthand by the experimenter. The advantage of this method over that of having the subject write the reproduced thoughts will be readily seen: a much shorter interval elapsed between the reading and the completion of the reproduction, a truer comparison being thus given between auditory and visual powers. Even by this method, in the short time required to reproduce one selection (auditory), much of the other (visual) would be forgotten. As a corrective of this a second test was made, with another pair of selections, and the order of reproduction reversed; that is, the visual passage was first recalled and afterwards the auditory. Auditory and visual tendencies were compared by the number of 'thoughts' reproduced from the original selections, these thoughts being divided into 'important' and 'minor.' A record was also kept of the number of 'extraneous thoughts' introduced. Not only was the correctness of reproduction considered but also the quality, in general as well as with regard to expression and to logical content. This is important in the calculation of the value of the reproduced material, as it might very well happen that one person would recall more thoughts than another whose reproduction on the whole, was much more creditable. In estimating quality, five grades—very good, good, fair, poor, and very poor—corresponding to those under visual perception, were taken into account.

This method of experiment would, of course, be in no sense a test of the relative powers of eye and ear if the subject intentionally gave more attention to one process than to the other. He was asked, however, to remember as much as possible of *each* selection, and the results show that in no case was the request disregarded. This test was an exceedingly difficult one, inasmuch as voluntary attention to two entirely distinct series of impressions, each involving for its interpretation very complex processes of thought, is quite impossible. The 'wave' of consciousness has but one crest. The 'doubling' of the mind is nearest approached in its "simultaneous application to two easy and heterogeneous operations; two operations of the same sort—two multiplications, two recitations, or reciting one poem and writing

another—render the process more uncertain and difficult."[1] The processes in the present test were neither easy nor heterogeneous, involving, as they did, not only the understanding, but the memory also, of the passages read and heard. The *sensory* processes, merely as such, could very easily go on simultaneously, one being auditory and the other visual. In the attempt, however, to focus attention upon two unrelated series of *ideas*, what actually took place, as testified by many of the victims of this experiment, was a flitting of attention from one to the other. The gaps thus resulting in the continuity of each series were repaired all too frequently by the imagination. Many spoke of a 'blacksmith' with 'curly locks' hanging down to his shoulders, the original selection being a description of a locksmith's shop with numerous locks hanging about the walls. The same idea was further followed out by such phrases as 'brawny arms,' 'honest sweat,' 'children passing,' all evidently called up from Longfellow's poem by unconscious association.

5. *Results of comparison by simultaneous processes.*—As in the other tests of eye and ear the auditory process has an advantage, though in this case it is very slight, the average reproduction of the material *heard* being 18.6 % of the total number of thoughts in the selection, while the percentage reproduced from the material *read* was 17.1. On the other hand, the quality of reproduction was slightly (4.3 %) higher by the visual method. The number of thoughts introduced which were not in the original selection was practically the same for both processes—in the auditory 4.2 % of the total number of thoughts reproducible from the selection; in the visual, 4.6. This tends to show that sound- and sight-images, in marginal consciousness, are equally liable to misinterpretation.

The correlation between rate of reading and visual-auditory ratio gives a result similar to that obtained from the memory-span experiment, namely, that eye-mindedness accompanies rapid reading. The curves (8) and the averages from which they are drawn are as given:

TABLE IX.

EYE-MINDEDNESS BY READING RATE (I.).

Class	XX	X	M	A	AA
Rate	3.9	4.4	4.9	5.8	7.3
Eye-mindedness	89.08	106.13	84.8	97.77	123.2

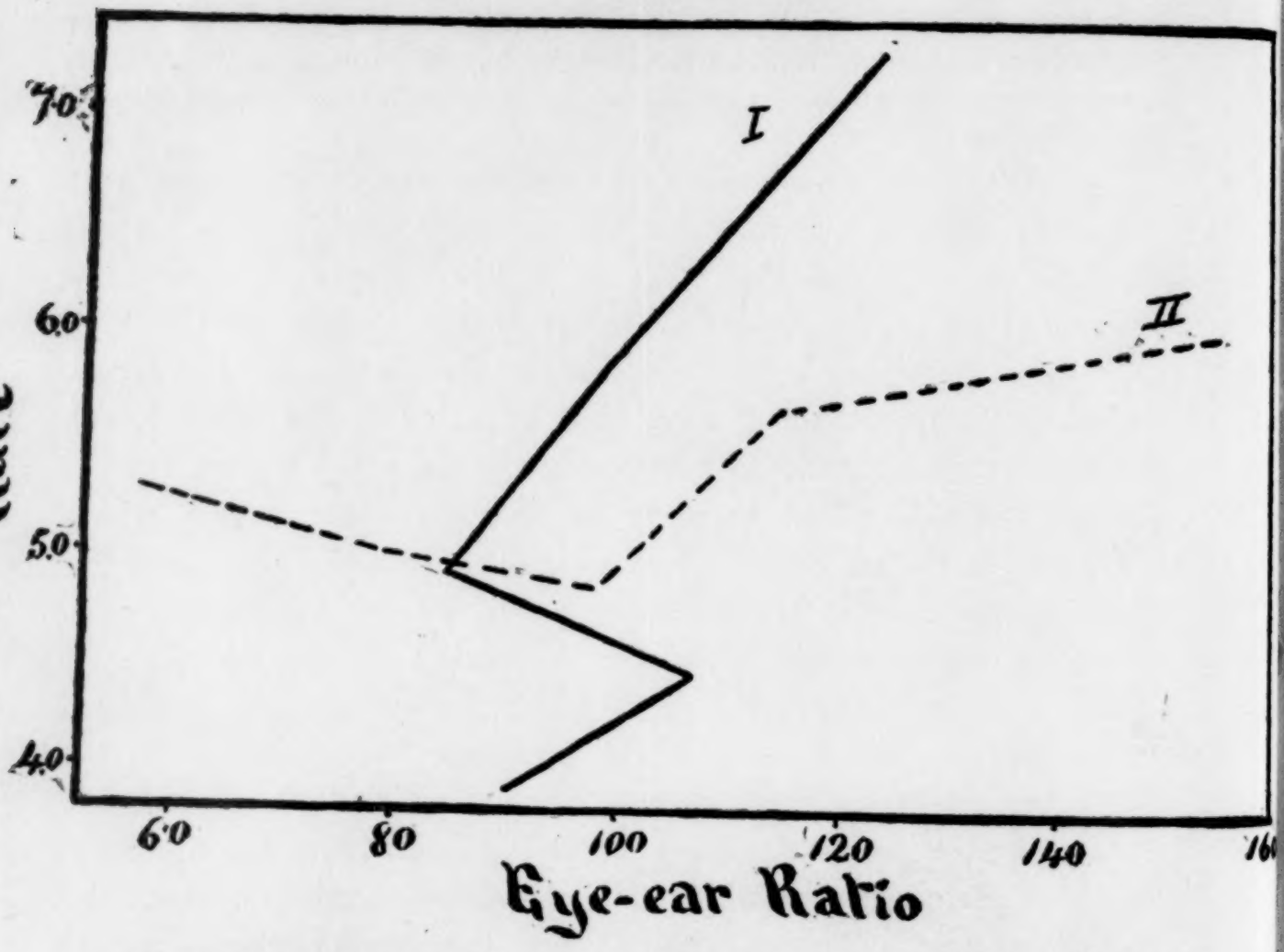
READING RATE BY EYE-MINDEDNESS (II.).

Eye-mindedness	57.0	78.7	96.8	114.2	154.1
Rate	5.25	4.99	4.82	5.61	5.95

[1] Paulhan, *Rev. Scientifique*, Vol. XXXIX., p. 684. Quoted by James.

The irregularity of these lines is due to the combination of two causes: the small number of records included (50), and the very difficult and complex nature of the experiment. The more complex the process the greater becomes the probability of accidental variations, and the larger, therefore, the number of records which must be included if the influence of chance is to be excluded.

Curve 8



The degree in which the rapid readers excel the slow in eye-mindedness can perhaps best be understood by a comparison of the extreme classes. The 'very slow' readers (3.9 words per second) reproduce 89.1% as much of the visual selection as of the auditory, while the 'very rapid' readers (7.3 words per second) are able to recall 123.2 of visual for every 100 of auditory; that is, the ratio of reading rates between slowest and fastest readers is 3.9 to 7.3 (1 : 1.87) while the ratio of the visual tendency as compared with the auditory is 89.1 to 123.2

(1 : 1.38). On the principle of correlations this result shows eye-mindedness to be a rather strong factor in the determination of reading rates.

It might be supposed that greater rapidity was gained at the sacrifice of exactness or of intelligence. This supposition is negatived by an examination of the amount and quantity of the material reproduced. A comparison between the ten most rapid readers and the ten slowest shows that the rapid readers remember more of the original thoughts, and that the character of their reproduction is much higher, both generally and with reference to expression and to logical content. In the auditory tests the ratio of slow to rapid readers is 14.8% to 20.7%, in the *number* of thoughts. In *quality* the percentages are 47.8 for slow readers, 60.3 for fast. The same comparison in the visual tests results as follows: percentage of thoughts reproduced by slow readers, 14.9; by rapid, 24.4. Quality: slow, 48%; rapid, 73.3. The difference in favor of the 'rapids' is consequently much greater than in the auditory tests, indicating again that rapid readers are, as a rule, of the visual type.

Combining both quality and amount of reproduction and both auditory and visual tests, thus making the comparison general, and continuing it throughout the different classes, we get the following numbers and curve (9) which show an increasing advantage to the rapid reader.

TABLE X.

RATE DETERMINING TOTAL REPRODUCTION (I.).

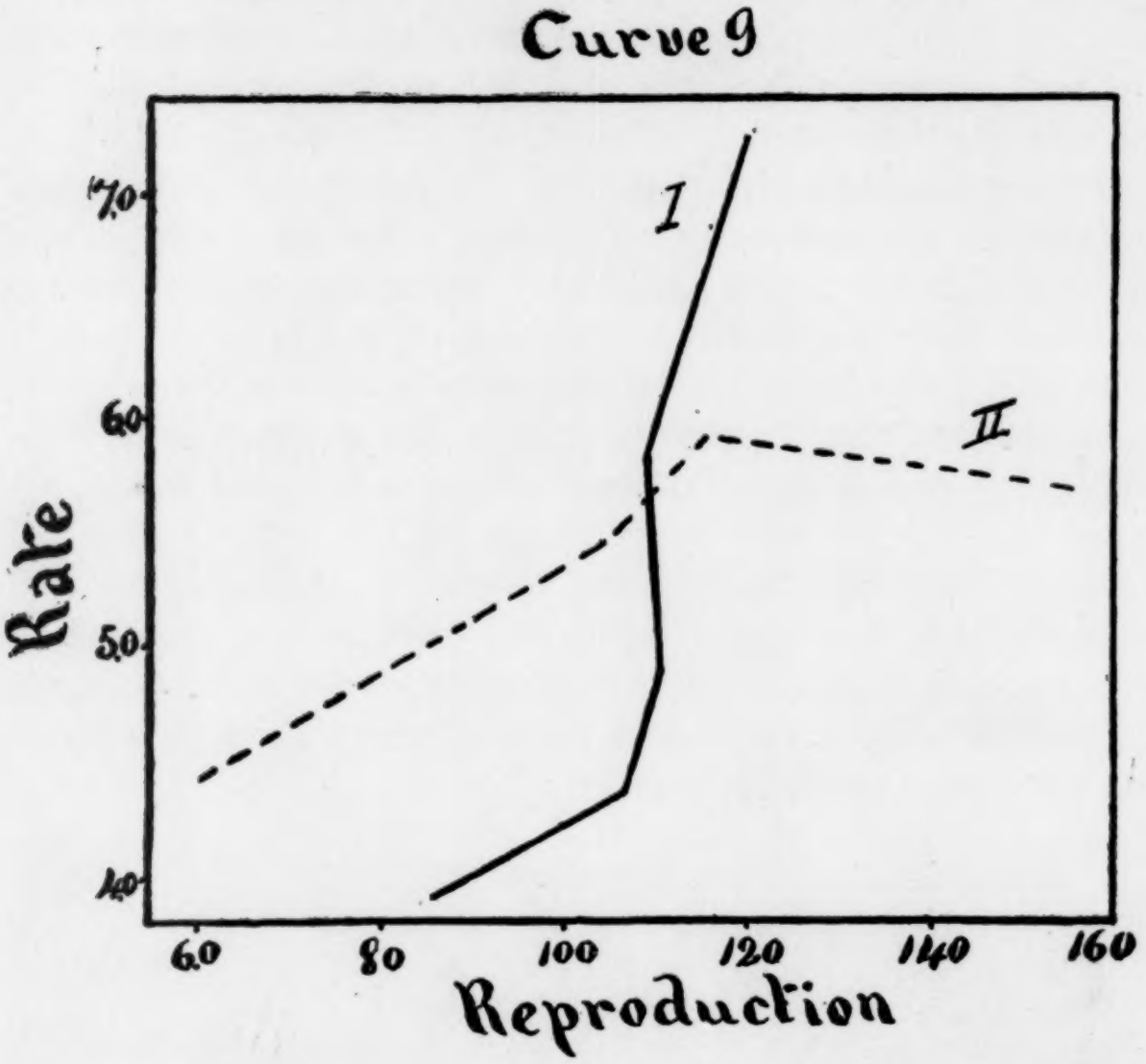
Class	XX	X	M	A	AA
Rate	3.9	4.4	4.9	5.8	7.3
Reproduction .	85.3	107.0	110.5	109.0	119.9

REPRODUCTION DETERMINING RATE (II.).

Reproduction .	60.0	89.3	104.3	115.6	158.2
Rate	4.42	5.15	5.45	5.91	5.64

In this test where eye and ear were used simultaneously, there is the possibility of rapid readers having a greater relative advantage than in recollection under ordinary circumstances. The effort of the subject in trying to grasp the meaning of both passages at the same time resulted, as already stated, in a rapid

alternation of attention between the two. The rapid reader would, therefore, have an advantage in being able more easily than the slow reader to catch up his own reading after his attention had been following the passage read to him. Nevertheless, both the preceding auditory-visual tests show the same result, and to a striking extent. In the memory-span test the rapid reader was superior to the slow by 26.7%; in the test by recognition of variations in the different readings the percentage



was 43.7; in the present test, of simultaneous processes, 40.5, (119.9 is 40.5% in advance of 85.3). These give an average of 37% by which the rapid reader is superior to the slow in quality of work. Among the causes of this result are probably differences in general intelligence.

The superiority of the rapid reader is also shown by the fact that his memory of the substance of his reading is more exact than that of the slow reader. He introduces only two-thirds as many thoughts not found in the original selections.

6. *Relation of intellectual ability to reading rate.*—Whether the supposition just made, that the degree of intelligence exercises some influence on rapidity of reading, is true to any considerable extent, is difficult to verify, since all tests of mental capacity are inadequate and unsatisfactory. Sensitiveness and sensibility have been suggested as tests. But these are only receptive powers and inferior to expressive. The dog, whose sense of smell is so much finer than our own, or the cat, whose acuteness of hearing surpasses ours, or the eagle, whose vision is many times keener, are not therefore our mental superiors even in these respects. Early youth is more sensitive than manhood, but does not possess greater mental capability, nor should we say that one's powers of mind had been greatly increased by an extended series of experiments which heightens sensibility in any of the senses. There is an intellectual as well as a sensational use of the senses.

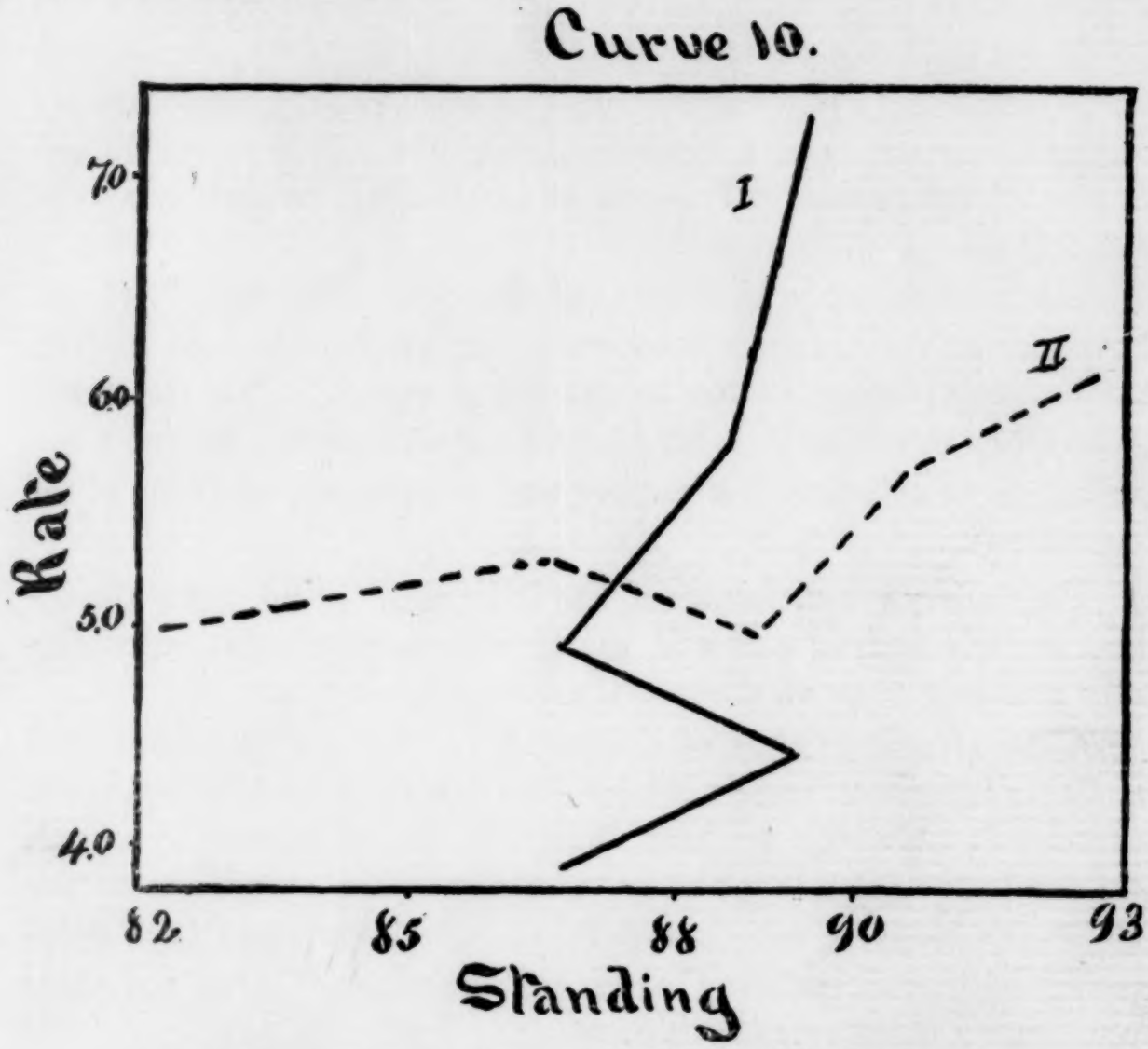
External tests are even less satisfactory. The weight of the brain, or its volume, is a measure of capacity only when we add the limiting phrase, 'other things being equal.' But the latest researches in cerebral anatomy and physiology are far from enabling us to calculate the variety and importance of these other conditions.

Any adequate estimate of the individual mind must doubtless include feeling and will, along with intellect, yet scientifically accurate tests of these are not easy to suggest.

Class standings are doubtless not a true test of even intellectual strength; geniuses have not been distinguished for brilliant work at school. Collegè records, however, are a means by which we can judge scholarly ability, and the class standings of the students who were subjects of these experiments are here compared with their reading rates. The result (Curve 10) does not show a close relationship.

7. *Major and Minor Thoughts.*—In the thoughts recalled in the 'simultaneous test' the auditory ratio of minor to major was nearly double the visual—24.8% and 12.9% respectfully. This does not necessarily mean that under ordinary conditions there is less distinction between the important and the unimportant when one hears a passage read than when one reads it himself. It does mean, in all probability, that such is the case under the conditions of this experiment; namely, when the attention is divided. It is true that the

reading aloud to the subject was intended to be rather unexpressive, as anything else would have defeated the main purpose of the test. It may be, therefore, that when one listens to expressive reading, and gives the whole attention to it, the foregoing discrimination in favor of the visual process will disappear, and the important thoughts will receive, in the selection heard, as great a relative attention as in the passage read, to the comparative disregard of the less important. Antecedently one would be inclined to pronounce in favor of the auditory; for the printed words are no more impressive, as mere symbols, when conveying a weighty thought than when only a trivial one; but the tones of the human voice, on the contrary, are much more impressive, being capable of great modulation to express shades of meaning and emotional qualities.



§ IV. The Motor Type and Lip-Movement.

1. *Method.*—Along with the eye and ear types goes another, less known but not less interesting, and, from certain points of view, not less important—the motor type. Persons of this type think in terms of the muscle sense—their images are 'myographic.' In silent reading they are, as a rule, lip-movers, or

at least imagine themselves speaking the words. It is especially in relation to lip-movement and its implications that this group is here studied.

The experimental method of determining motor readers was as follows: Three passages of equal length and difficulty were read silently by the subject, all at the maximum rapidity at which he could read intelligently. The first was read under normal conditions; that is, with no external restrictions. During the reading of the second the subject was required to hold the tip of his tongue underneath his upper lip, thus interfering greatly with the free movement of his lips, if he were a lip-mover, and, consequently, interfering with his attention, and thereby decreasing his reading rate. If he were of the motor type, yet not a lip-mover, this position of the tongue would still interfere with his imagining the position of the vocal organs, just as it is difficult, when lying down, to imagine one's self running, because the position hinders tendencies to movement which accompany the idea of running. By way of comparison with this second test a third selection was read under conditions which introduced an equal interference with attention but not with lip-movement—the subject kept up an approximately uniform pull on a dynamometer, varying in amount with different individuals, according to their strength.

Other methods of determining lip-movement were employed: observation by the experimenter (unsuspected by the experimentee), as well as the latter's own judgment, expressed after he had taken a few days to study introspectively his own reading habits. (See appendix, 'Personal Sheet.')

2. *Results.*—The results obtained by these methods agree fairly well. That they do not agree perfectly arises from the facts (1) that one's judgment of his own methods of reading, unless he be a somewhat skilled self-observer, may be at fault, and (2) that the observation by the experimenter was confined to too few tests of the reader's habits to be conclusive. In the following table are given in percentage the subject's own estimate of his lip-movement in general, and also the observation of it by the experimenter in particular kinds of reading. The column designated 'careful reading' is the case in which the subject

read very attentively with a view to detecting variations in the two readings of the same selection (the second comparison between eye and ear, above). 'Normal reading' means simply ordinary silent reading under normal conditions. 'Rapid' refers to the maximum rate of intelligent reading.

TABLE XI.—LIP-MOVEMENT.

	Observation by Experimenter.				Subject's own Estimate.
	Careful Reading.	Normal Reading.	Rapid Reading.	Average.	
Decided Movement .	25·5	0	5·7	10.4	2.1
Medium Movement .	35·3	28.6	24·5	29·5	35·4
No Movement . . .	39·2	71·4	69.8	60.1	62.5
Total	100	100	100	100	100

The average as observed thus corresponds pretty closely to the subject's own estimates, the differences here, as elsewhere, indicating that the subject is inclined to be somewhat generous to himself.

3. *Nature of lip-movement.*—To gain an understanding of the real nature and significance of lip-movement in silent reading we must know something of its origin. To answer the theoretical question of how it arises may give us a deeper insight into the nature of it, and thus aid us in answering the practical question of how to deal with it. The argument can be most definitely focused by marshalling the facts about a conclusion stated somewhat as follows: Lip-movement in silent reading is not an acquired habit, but a reflex action, the physiological tendency to which is inherited. It is not 'second nature' but essentially first nature; not something to be *unlearned* but to be *outgrown*. It is a specific manifestation of the general psycho-physical law of 'dynamogenesis' by which every mental state tends to express itself in muscular movement.

In support of this the following considerations are adduced:

(*a*) The child in learning to read does not learn to move

his lips. The lip-movement is most decided at the very beginning, and grows less so, as he becomes conscious of it and controls it voluntarily. In learning to write, also, the child moves his tongue and the muscles of his face; sometimes even his feet or his whole body. But he afterwards finds that this expenditure of energy is unnecessary. It is brought under control when the writing itself becomes partially reflex, leaving the higher conscious processes more free to attend to the inhibition of these lower useless ones. The same act is then performed more exactly, more quickly, and with less exhaustion. Similarly, lip-movement is an unnecessary expense of energy — not only useless but detrimental.

(*b*) In the answers to the 'personal sheet' many persons say that though not habitual lip-movers they do move their lips when giving very close attention, or when reading matter which is very difficult, absorbingly interesting, or highly emotional. This means simply that we regularly inhibit these vocal reflexes, but that when our whole attention is given to the thought under consideration the watchfulness over these motor tendencies is relaxed, and they find expression. We tend to 'think aloud' when pre-occupied — not only lip-movement but actual speech is unintentional. It is true also that these impulses to vocal movement are stronger, and hence more likely to find an outlet, when the corresponding mental processes are more vivid. This follows from the general principle, experimentally demonstrated by Féré,[1] that "the energy of a movement is proportional to the intensity of the mental representation of that movement."

(*c*) Some students state that lip-movement aids concentration and comprehension. This is negatived by the comparison of lip-movers' work with that of non-lip-movers (Curve 13, below). Instead of lips being moved as an aid to close attention, the causal relation is in the opposite direction: the close attention is the cause, or rather the condition, of the lip-movement (as in *b*, above). Careful introspection will verify this; many of us who are decidedly not 'motaires,' will often 'catch' ourselves moving our lips and tongue while we are struggling with a para-

[1] *Sensation et Mouvement.*

graph from Kant or Lotze. That is, the beginning of the movement is not conscious and deliberate. It is therefore an aid to concentration only negatively—by the expression of itself in a natural way it leaves the whole attention free to be focused upon the immediate content of consciousness. It ought to be added that lip-movement is doubtless an indirect aid to comprehension and retention from the mere fact that it lengthens the *time* of reading. (Curve 11.)

(*d*) This interpretation is supported by the results of observation, given in Table XI. In careful reading when the fullest attention is given to the thought a higher percentage of decided lip-movement is shown than in ordinary or in rapid reading, and those who show no movement are a very much lower percentage. At first view we should be inclined to say that in rapid reading also the inhibitory process would be completely relaxed and the motor tendencies would express themselves strongly. But this is shown only slightly as compared with the 'normal' column. The reason is doubtless that in reading at a maximum rate we employ the visual process almost exclusively, and we cannot easily perform even the beginnings of articulation so rapidly.

(*e*) The statement that lip-movement is 'natural,' and reading without lip-movement an acquired habit, is entirely in accord with mental laws. The development of mind is not only in handing over processes, once conscious, to the control of the reflex mechanism—as in walking or in playing a familiar tune on the piano—thus leaving consciousness free for the acquisition of higher powers and the performance of tasks more difficult; but the interchange is also in the opposite direction—originally reflex processes are frequently brought under the control of the higher consciousness, and inhibited if they are considered useless or detrimental.

(*f*) The mental growth of the child is in general parallel with the growth in culture from primitive to highly civilized races. The close connection between thought and action is best seen in children and in uncivilized peoples who have not learned to repress the motor accompaniments of thought and emotion. As we rise in the scale of intellectuality people become less demonstrative, until we reach the highly educated and intellectual, who are proverbially 'cold.'

(*g*) A supplementary argument might be drawn from the 'law of reversion,' by which the latest acquired is the earliest to be lost, in diseases of memory or in senile dementia. Innate physiological tendencies, therefore, would be the last to go. Observation shows the tendency to lip-movement to remain when the power to use language intelligently has been lost.

This position is not invalidated by the fact—if it be a fact—that "every child, if removed early from its parents, can learn to master any language whatever, instead of its mother tongue, and just as perfectly as that."[1] The inherited physiological tendency may be toward the use of speech without being toward any one language in particular until the child begins to use language.

The pedagogical value of this interpretation of lip-movement is evident. On our understanding of the child's mind depends our intelligent direction of it. Knowing that certain practices, instead of being mischievous habits, acquired through carelessness and deserving of censure, are but the natural expression of inevitable physiological tendencies, we shall be able to deal with them more sympathetically. It may be desirable that the child or the adult should escape from the retarding influence of lip-movement in reading; knowing the nature of the imperfection will enable him more wisely to direct his efforts in outgrowing it.

4. *Correlation of Lip-movement with Reading Rate.*—The relation between rate and lip-movement is seen in the following table and correlation. (Curve 11.)

MOTOR TENDENCY DETERMINED BY READING RATE (I.).

Classes	XX	X	M	A	AA
Rate	3.9	4.4	4.9	5.8	7.3
Motor	8.4	6.6	5.3	4.7	4.5

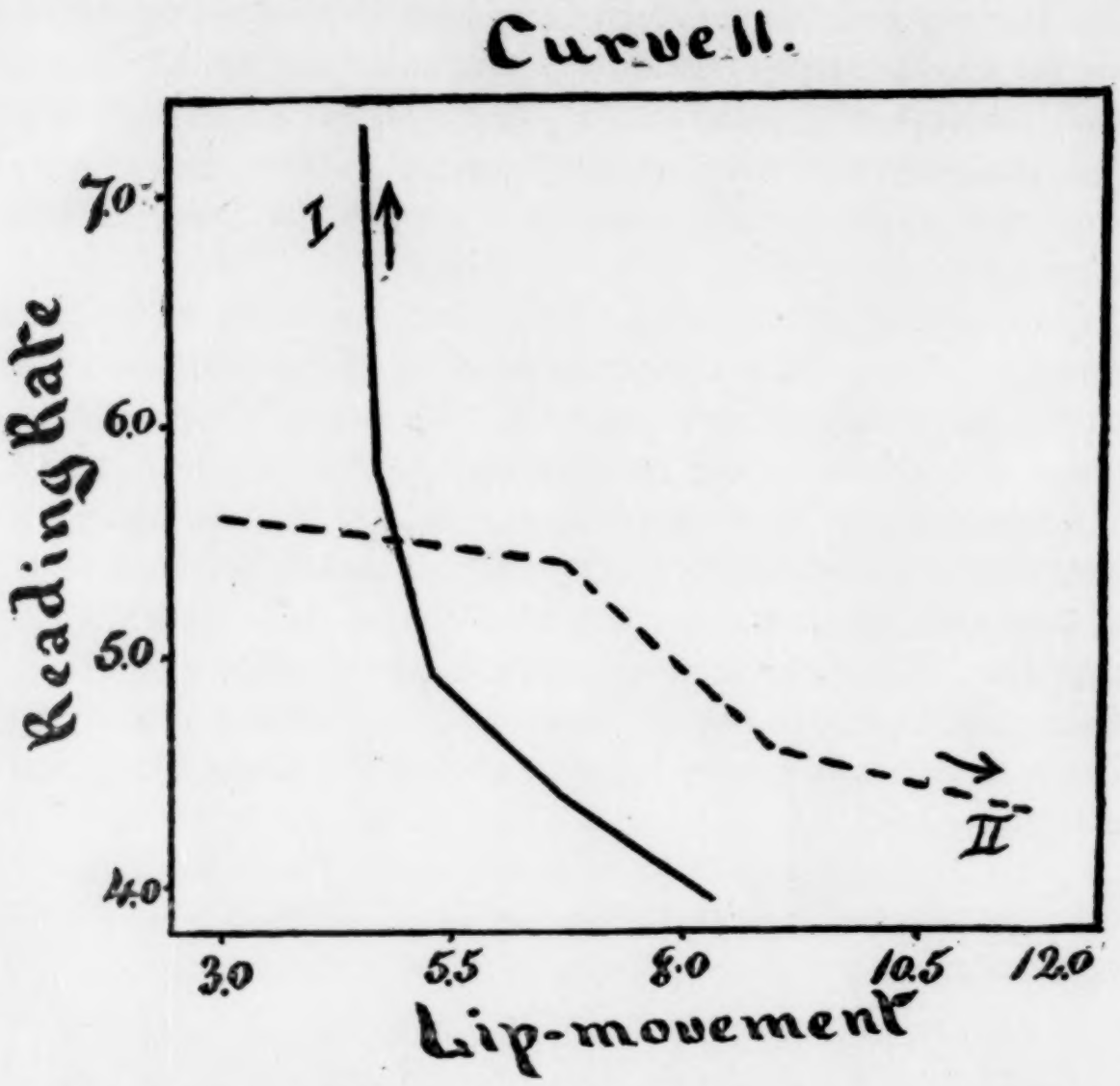
RATE BY MOTOR TENDENCY (II.).

Motor	3.0	4.9	6.7	9.0	11.7
Rate	5.6	5.5	5.4	4.6	4.3

This shows that the motor tendency in any degree has an influence detrimental to rapidity of reading, and the stronger the tendency the greater is the hindrance; the numbers represent-

[1] Preyer, *Infant Mind*, p. 121.

ing the lip-movement regularly decrease as reading rate increases, and *vice versa*. The curves, so far from having any tendency to approach the (N.E. – S.W.) diagonal of the rectangular plot, toward which they would tend if lip-movement were a furthering influence in speed of reading, cross this diagonal almost at right angles, thus demonstrating clearly the fact that the reciprocal influence is adverse.



To emphasize this relation a comparison of extremes might be shown as follows: The ten slowest readers show almost double the amount of lip-movement that the ten most rapid do. Or again, determining rate by means of lip-movement, we have: the ten most decided lip-movers read 4.1 words per second; that is, they are between the classes 'slow' and 'very slow,' and nearer to the latter; while the ten who show least movement of lips read 5.6 words per second,—very close to an average 'rapid.'

When the visual tendency is combined with the motor the lip-movement is not so decided as in the auditory-motor combination.

5. *Lip-movement and Extent of Reading.*—Bringing together this result of the relation between lip-movement and reading rate, and that reached later (Curve 16) between amount of practice and rate of reading, we should expect that lip-movement and extent of reading from childhood would be in inverse ratio. That is to say, the ratio between rate and lip-movement being inverse, and that between rate and extent being direct, the ratio of lip-movement to total amount of reading ought to be inverse. A direct comparison shows this to be true. (Curve 12.)

TABLE XII.

LIP-MOVEMENT AND EXTENT OF READING (I.).

Class	XX	X	M	A	AA
Reading		25	30	35	40
Motor		7.7	6.2	5.7	3.0

READING BY MOTOR-TENDENCY (II.).

Motor	3.0	4.9	6.7	9.0	11.7
Reading	33	29.4	28.3	31.5	26.7

The lowest parts of these curves run almost exactly in opposite directions, as do also the highest. The interpretation of this is, that extent of reading works directly against movement of lips, and is practically the only thing which does so, except among the medium lip-movers, where other factors seem to enter. The general result here obtained is strengthened by the observation that all *AA*'s in amount of reading are *XX*'s in motor tendency; that is, not one of those whose reading is widest is a lip-mover to any extent which can be observed.

6. *Relation between motor-mindedness and quality of intellectual work.*—In the test between eye and ear by means of simultaneous processes (§3, Par. 4.), the more distinctly a subject belonged to the motor class the smaller the amount of material was he able to reproduce from the selections. All the thoughts recalled from both the auditory and the visual selection, together with their relative value (estimated by a necessarily conventional standard) were added for each subject

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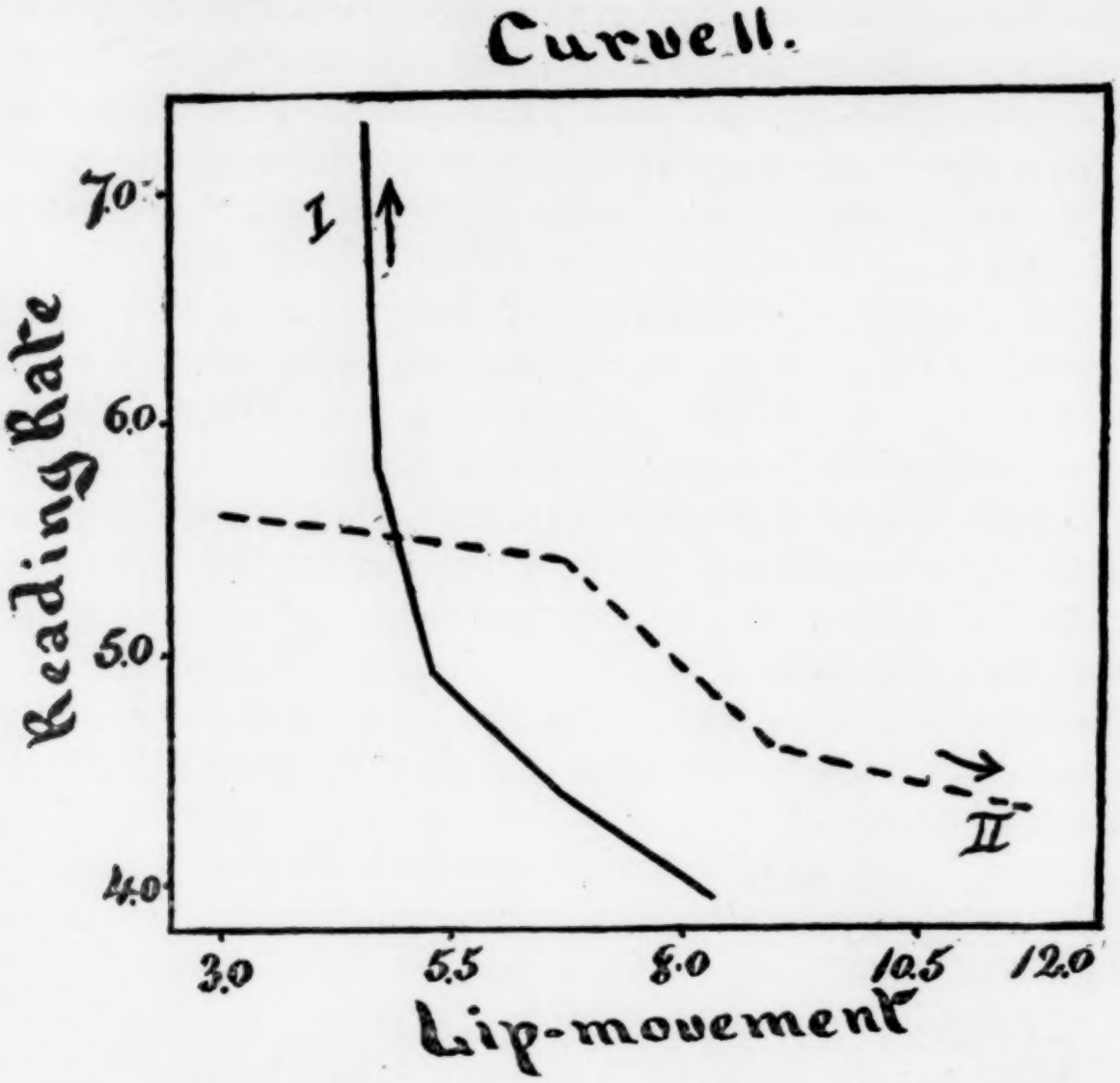

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separately, and this sum was compared with the strength of his motor-mindedness. The former increased regularly as the latter decreased, as shown in Table XIII and Curve 13.

Curve 12.

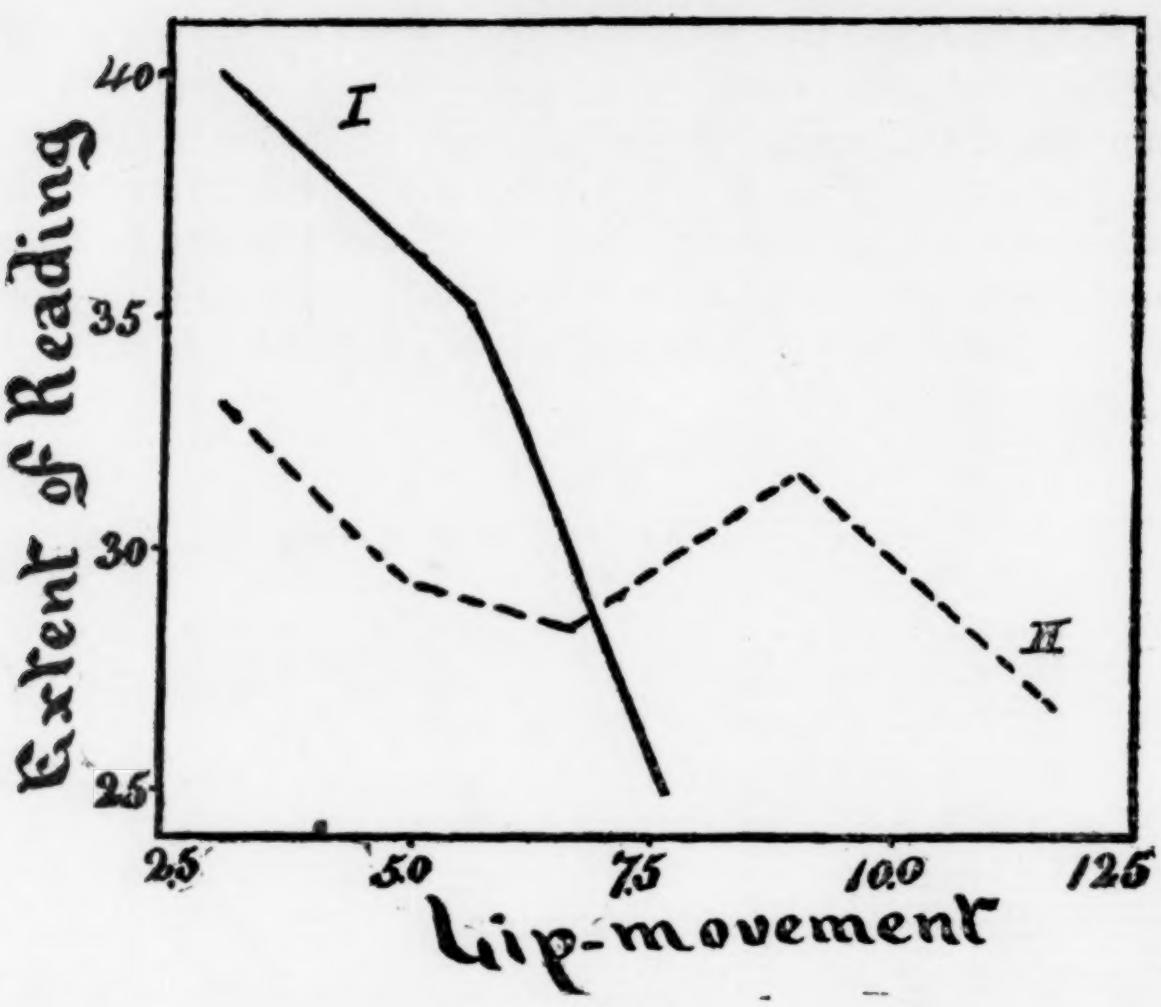
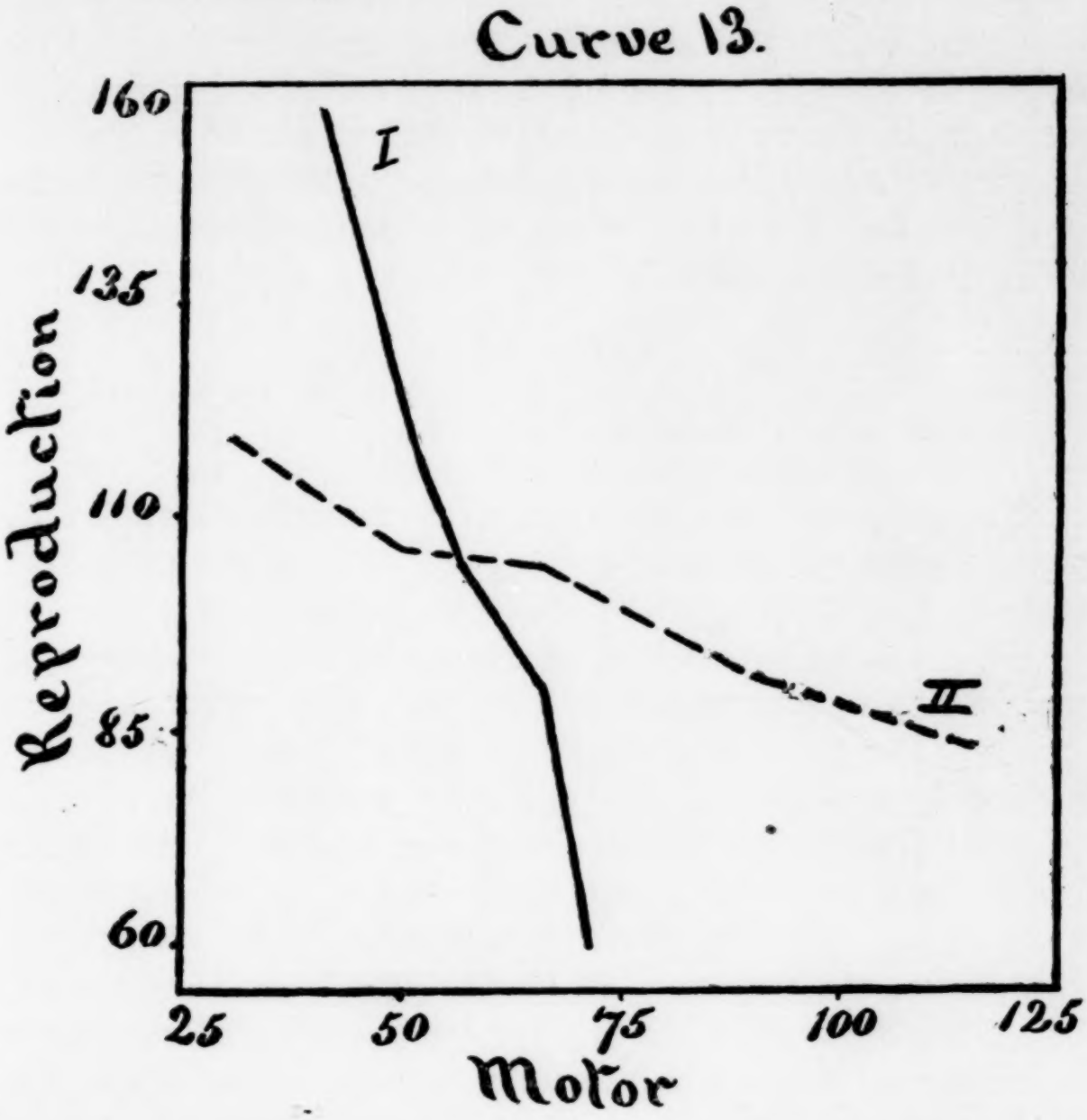


TABLE XIII.

MOTOR-MINDEDNESS AS DETERMINED BY REPRODUCTION. (I.).					
Class	XX	X	M	A	AA
Reproduction	60	89.3	104.3	115.6	158.2
Motor	7.2	6.7	5.7	5.2	4.2
REPRODUCTION BY MOTOR-MINDEDNESS (II.).					
Motor	3.0	4.9	6.7	9.0	11.7
Reproduction	118.0	106.7	104.8	91.8	83.8

This, in itself, does not prove that motor-minded persons are less intelligent readers than auditory- or visual-minded. As has been shown, those of the motor type are slow readers, and are probably, therefore, at a greater relative disadvantage in a test of this kind than in any test under ordinary conditions, where only one passage is read at a time and afterwards re-

called. Still, it is evident that motor-mindedness is far from being an advantage to a reader, either as regards the time required for reading or the amount obtained from it.



§ V. Other Determining Factors of Rapidity of Reading.

1. *Agreement of Personal Judgment with Experiment.*— From the answers to questions of the 'personal sheet' other factors influencing rate of reading were determined. These answers are probably less exact than scientific experiment would furnish; yet a comparison between the two sources of information shows a closer relation than might be expected. The tests of reading rates were compared with the students' own judgment of the same. In a few cases the personal equation is

quite strongly marked. One man calls himself a 'very slow' reader whose rate in reality is higher than that of another who classes himself as 'medium;' another estimates his speed as 'rapid' whose rate is below that of one who calls himself 'slow.' But these are the rare exceptions; as a rule there is great uniformity between the personal judgments and the literary tests; for example, all those who class themselves as 'slow' readers, with a single exception, are found by test to be within the limits of four to four and a half words per second. The comparison throughout stands thus:

TABLE XIV.

Class	XX	X	M	A	AA
Rate according to experiment	3.9	4.4	4.9	5.8	7.3
Rate according to self-judgment	4.2	4.3	4.9	5.9	7.8

These figures show the average rate for each class; that is, 3.9 words per second is the average rate of those who are classed according to the experiments as 'very slow,' and 4.2 is the average rate, by experiment, of those who class themselves by their own judgment as 'very slow;' and similarly for the other grades. The correspondence between the two methods of classification is thus seen to be very close, except in the extreme classes. The reason for the divergence here is (1) that in the lowest class the number of individuals who are willing to call themselves 'very slow' is so small that the figures are not representative, the variation of 'judgment' from 'experiment' being merely accidental, (2) the most rapid readers show a characteristic modesty in hesitating to place themselves in this highest class. This raises their average above that of the classification by experiment.

2. *Mental Alertness and Reading Rate.*—Taking alertness of mind to be correctly estimated by one's own judgment of his degree of rapidity in composition, the curve connecting this with reading rate is given below. (Curve 14.)

Rapidity of composition is probably a more adequate test of the quickness of mental process than most laboratory tests would be. Multiplication and similar mathematical tests depend too much on practice; 'finding time' involves too large a physiological element, and complex reaction-times are necessarily too specific to furnish a true test of general quickness of mind.

3. *Mental concentration and reading rate.*—Obviously one can perform mental operations more rapidly when the mind is strongly concentrated on the work than when the attention is divided. Power of concentration was therefore compared with speed of reading, with the following result, giving Curve 15.

Curve 14.

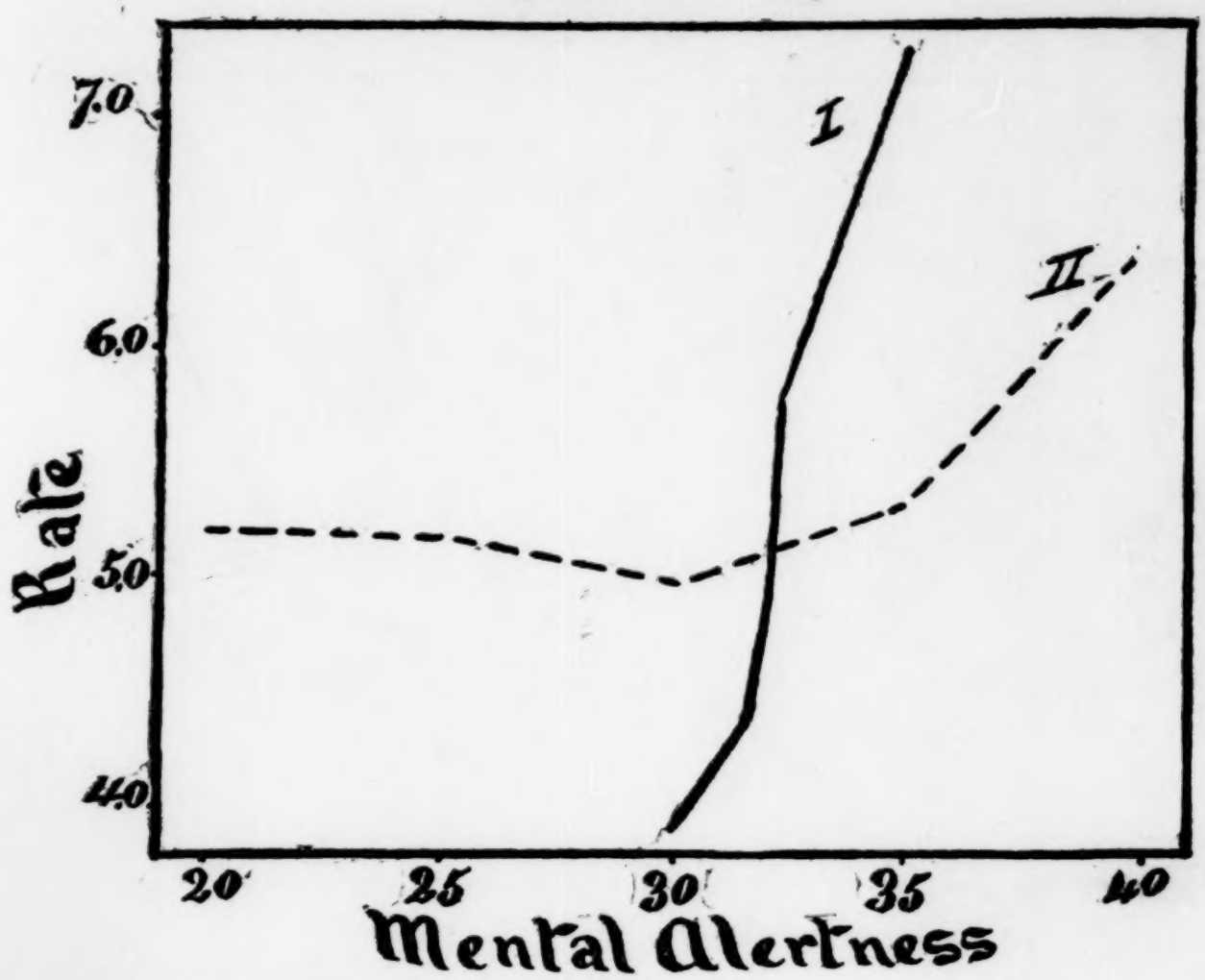


TABLE XV.

READING RATE DETERMINED BY POWER OF CONCENTRATION (I.).

Classes	XX	X	M	A	AA
Concentration	20	25	30	35	40
Rate	3.7	4.8	50.0	5.3	7.4

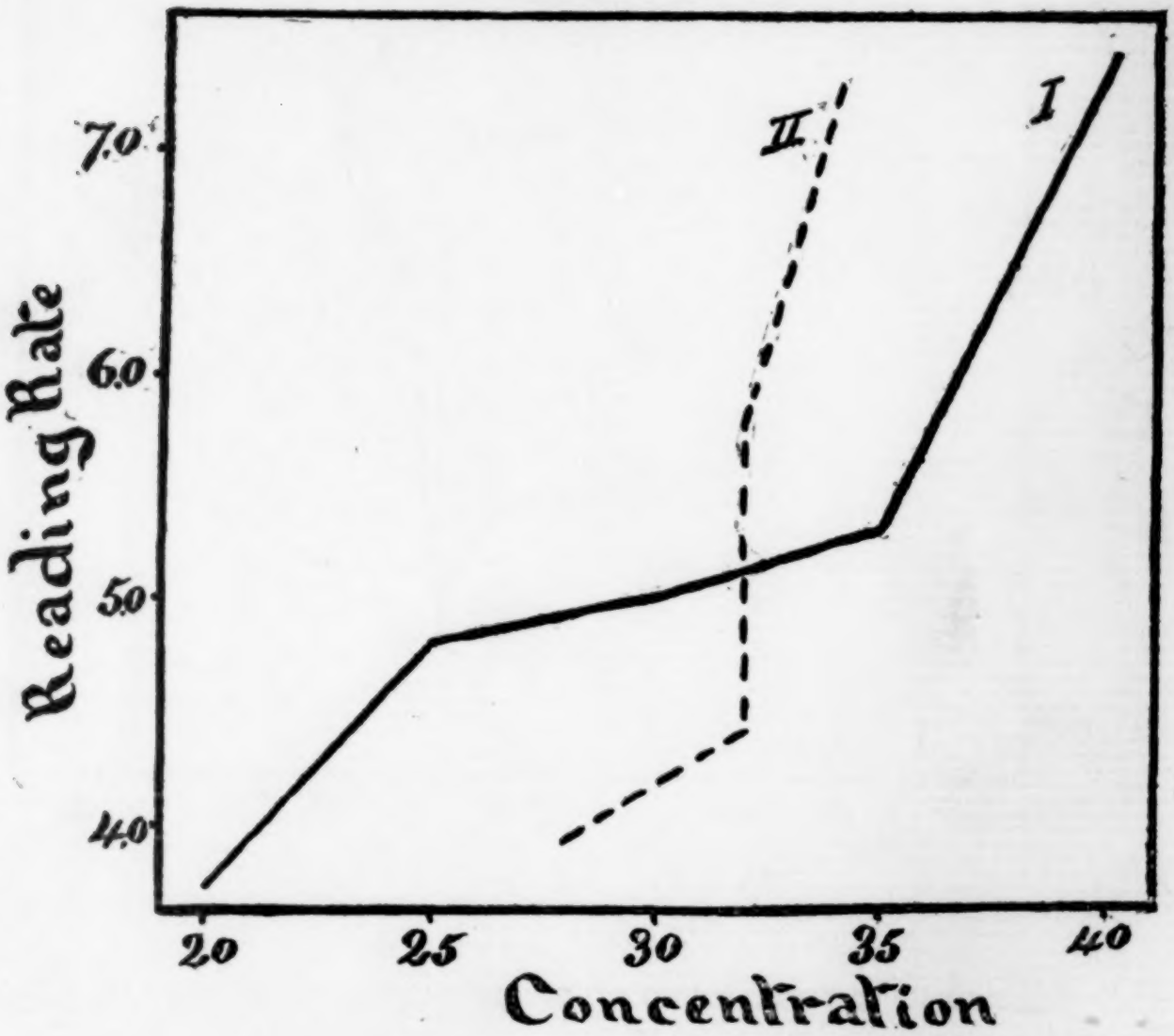
CONCENTRATION BY RATE (II.).

Rate	3.9	4.4	4.9	5.8	7.3
Concentration	2.8	3.2	3.2	3.2	3.4

The lower ends of the curves have the same general direction. This evidently means that poor concentration tends to hinder rapidity of reading. The curves, moreover, are nearly parallel at the upper ends; that is to say, high reading rate

accompanies unusually good powers of concentration. On the other hand, the curves cross almost at right angles; consequently there is little relation between rate and concentration in the three middle classes. In a word, the greatest and least degrees of concentration affect reading rates favorably and adversely, but greater or less degrees do not.[1]

Curve 15.



4. *Practice and reading rate.*—Practice was also tested as a possible factor in rapidity. Here again the subject's own judgment was necessarily taken. Information as to the extent of his reading from childhood up could be obtained in no other way. The result (Curve 16) shows a rather close correlation.

[1] This conclusion is merely tentative. In a thorough study of the influence of concentration it would be necessary to consider the relation between the sensory type of the subject and the nature of the distraction, *e. g.*, an 'auditaire' would be easily disturbed by noises, a 'visionaire' by sights.